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RESEARCH PERSPECTIVES

ABSTRACTS OF Ph. D. THESES 1983

PART II

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RESEARCH PERSPECTIVES

ABSTRACTS OF Ph. D. THESES—1983

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O. P. TANDON

BANARAS HINDU UNIVERSITY

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INDIA

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कृपया पुस्तक के ऊपर कोई निशान आदि
न लगायें।

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RESEARCH PERSPECTIVES

DONATION

(Abstracts of Ph. D. Theses—1983)

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PART II
(SCIENCE)

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COMPILED AND EDITED BY
O. P. TANDON
Officer on Special Duty
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BANARAS HINDU UNIVERSITY, VARANASI 221005
1986

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Foreword

It was my privilege to release the Part I of this volume immediately after my taking over as Vice-Chancellor of this great University. I am happy that within a year the other part of the second volume of Research Perspective—Abstracts of Ph. D. Theses (1983) is in our hands. The readers will remember that Part I consisted of Ph. D. theses done in the area of Humanities and Social Sciences. Part II presents the abstracts of theses submitted in the Science sector.

This series of Publication is undoubtedly a significant service being rendered by Officer on Special Duty (Academic & Examinations) and his colleagues and associates as the result of enormous research conducted in this University, are made available to the world of knowledge in a short time.

I hope that this useful work will be carried forward and I am sure that this publication will receive a positive response from individual scholars and Institutions alike.

R. P. Rastogi

Vice-Chancellor

Varanasi

March 19, 1986

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Editorial Note

The second volume of 'Research Perspectives' containing Abstracts of Ph. D. Theses—1983, has been divided in two parts—Part I consists of the Ph. D. research work done in the Faculties, broadly labelled as Humanities and Social Sciences. Part II covers the abstracts of theses submitted in the Faculties of Agriculture, Engineering and Technology, Indian Medicine, Medicine and Science. This arrangement has been made to distribute the volume of work in a more meaningful and useful manner besides managing the physical aspect of this annual research contribution. 327 Ph. D. theses were approved in 1983. Out of this, 180 belong to the Humanities and Social Sciences area and the remaining 147 belong to the discipline of Sciences.

The profound academic interest taken by Prof. R. P. Rastogi, Vice-Chancellor, Banaras Hindu University in enriching the academic life continues to draw us to greater involvement in contributing our mite towards this cause.

As on previous occasions, I have received cooperation and assistance both from the colleagues in the administration and some of the University dons. A few names, however, deserve special mention in preparation of this volume. They are Prof. S. N. Lal, Prof. R. S. Ambast, Dr. Ajit Sodhi, Prof. C. Suryanarayana, Prof. M. N. Mehrotra, Prof. O. P. Malhotra, Prof. R. M. Singh and Dr. (Miss) Vidula Jayaswal. I record my sense of gratitude to them. Shri S. P. Mukherjee, Deputy Registrar and Shri R. B. Agrawal, Assistant Registrar in the Academic Section and Shri D. P. Bhattacharya and Sri S. S. Rahman in the Controller of Examinations' Office have rendered valuable assistance and I am very grateful to them.

I also record my thanks to M/S. Tara Printing Works for printing this volume as well. My wife and daughters have all along cheered me up in this pursuit inspite of my failings towards them. I have no words to express my appreciation of their understanding.

Holi
March 26, 1986.

O. P. TANDON

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Faculty of Agriculture

AGRICULTURAL ECONOMICS

MARKETING OF RICE IN ANDHRA PRADESH

B. Sesha Reddy Sup. : *Dr. S. B. L. Gupta*

The second generation problems of the Green Revolution, most importantly those of marketing of farm products, remain unsolved as agricultural planning and development entered the eighties. Solution to these problems calls for concerted efforts in research and development covering various facets of agricultural marketing. Of the several institutional innovations attempted in the past in handling marketing problems in Andhra Pradesh, regulated market is unique for its specific bias for protecting the interest of the farmers through orderly marketing.

Rice is a predominant crop and also a regulated commodity in Andhra Pradesh. The price of rice varies considerably from place to place, season to season and year to year because of speculative activities of the middlemen. No systematic attempt has so far been made in Nalgonda district to study the reasons for such fluctuations and to work out the market margins. Considering the fact the present study entitled, "Marketing of Rice in Andhra Pradesh", has been attempted with the following specific objectives:

(i) to study pattern of production, on farm utilisation and disposal of surplus paddy;

(ii) to study the determinants of marketed surplus; and

(iii) to study marketing costs and charges and price spread in selected markets.

The hypotheses formulated and tested in the study are:

(i) the marketed surplus of paddy is influenced by size of family, area under paddy and price received for paddy;

(ii) there exist differences in prices of paddy due to the differences in volume of marketed surplus; and

(iii) there exist differences in market margins due to the differences in the channels of marketing in the regulated markets.

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The multi-stage sampling procedure was adopted for selection of markets, villages and farmers in the study.

Nalgonda district comprises of 10 market committees, out of which two having largest volume of paddy handled in the market, namely, Miryalaguda and Suryapet, were selected.

Around each selected market, the villages were stratified in the following three categories:

(i) villages located upto a distance of 10 kms, or less from the selected market connected by a country road upto 80 per cent or more of the distance;

(ii) villages located upto a distance of 10 kms, or less from the selected market and connected by metal or fair weather roads upto 80 per cent or more of the distance; and

(iii) villages located beyond a radius of 10 kms., from the selected market and connected by metal or fair weather roads upto 80 per cent or more of the distance.

From each category, the village having maximum total area under paddy cultivation was selected. Thus in the two markets six villages were selected.

A list of farmers along with their size of holding in the selected sample villages was prepared with the help of the concerned revenue records. From this a list of predominantly paddy growing farmers was prepared and listed in an ascending order according to their size of operational holding during the year 1977-78. The list was divided into five segments as given below:

Size group— I : Upto 1.00 hectare—Very small size farmers.
Size group— II : 1.01 to 2.00 hectares—Small size farmers.
Size group— III : 2.01 to 4.00 hectares—Medium size farmers.
Size group— IV : 4.01 to 8.00 hectares—Large size farmers.
Size group— V : 8.01 hectares and above—Very large size farmers.

Five farmers were randomly selected from each size group in each village. Thus the total sample consisted of 150 farmers, i.e., 25 farmers per village.

The market functionaries in the selected markets are basically of two types, namely, commission agents and traders. In each market a list of such functionaries was prepared and 15 market functionaries were randomly selected. Thus the study covers 30 commission agents

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and 30 traders in addition to the Food Corporation of India. Field information was collected through repeated personal visits to the farm families. The study relates to the year 1978-79.

The intensity of irrigation as well as cropping intensity in both the market areas, viz., Miryalaguda and Suryapet are quite high. However, both these show a decreasing trend with the size of farm. An increase in the area and production under paddy with the increase in farm size has been observed in both the market areas, whereas the productivity generally shows a decreasing trend with the size of farm. The percentage of marketable surplus has a direct relationship with size of farm. However, the percentage of marketed surplus is generally less than marketable surplus due to the withholding of stocks by the farmers. The percentage of marketed surplus to marketable surplus, current year production and total receipt of paddy was found highest among the small farmers in both the market areas under study.

The examination of pattern of paddy arrivals and the structure of prices reveals that the trend in prices was in accordance with the trend of arrivals due to the existence of competitive marketing system. The average price received per quintal of paddy has increased with the size of farm as a result of an increase in the volume of marketed surplus. This may be due to economics of scale. Thus, the second hypothesis, namely, "there exist differences in prices of paddy due to differences in volume of marketed surplus" is accepted.

The overall costs as well as market margins were higher in the case of private traders than the Food Corporation of India. Thus the third hypothesis, that there exists differences in market margins due to the difference in the channels of marketing in the regulated markets is accepted.

Multiple regression analysis was carried out to ascertain the impact of various factors on marketed surplus The three variables included in the analysis are the size of family (adult units) (X_1), area under paddy in hectares (X_2) and the price received per quintal of paddy in rupees (X_3).

The regression coefficients for area under paddy have been found significant at 1 per cent level of significance in different size groups and all size of farms in both the Miryalaguda and Suryapet markets. The regression coefficient of marketed surplus on area under paddy is positive which indicates the rate of increase in marketed surplus with an increase in area under paddy. The regression coefficient of marketed

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surplus on price received for paddy is positive which shows that there is a trend of increase in marketed surplus with an increase in price received for paddy. Further, the marketed surplus is more responsive to price on comparatively larger farms and is not responsive in case of small and medium farms, due to comparatively lesser produce generated on small and medium farms which is invariably sufficient to meet the household requirements only.

The regression coefficient of size of family is negative for all the size groups indicating that it has an inverse relationship with the marketed surplus. Therefore, the marketed surplus is influenced by area under paddy and the size of family. Thus, the first hypothesis, namely, the marketed surplus of paddy is influenced by size of family, area under paddy and price received for paddy is accepted for the first two variables only.

STRUCTURAL CHANGES ON AGRICULTURAL HOLDINGS AND THEIR IMPACT ON FARM RESOURCE PRODUCTIVITY IN JAUNPUR DISTRICT

Chinta Mani Tiwari Sup. : *Dr. B. D. Shukla*

The process of sub-division and fragmentation of holdings has been a major obstacle in the way of agricultural development. The well-known disadvantages of the sub-division and fragmentation of farm holdings become more serious in case of small farms. Majority of the holdings in India are not only small but widely scattered. The most obvious effect of dividing a farm into a number of physically separated parcels is to make the working of farm unnecessarily inconvenient and time consuming. In case of unavoidable fragmentation, some handicaps are a foregone conclusion. Time is wasted and extra expenses are involved in moving workers, animals, crucial inputs and implements to and from the farm stead and from one field to another. Supervision is rendered more difficult and expenses on water supplies are much larger.

Therefore, a systematic programme is to be adopted in tackling the overall economic development of the farming community. Under the situation like ours consolidation is preferred as an ideal approach because of farmers' preference to individualistic private family farming.

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The present study therefore, has been proposed to be undertaken with the following objectives:—

(1) To examine the structural changes on consolidated and non-consolidated farms.

(2) To examine the impact of consolidation on cropping pattern.

(3) To compare the intensity of input uses on consolidated and non-consolidated farms.

(4) To compare the farm resources, resource-productivity between consolidated and non-consolidated farms.

(5) To estimate the different measures of farm profits on both categories of farms in the study area.

A brief review of literature and work done on consolidation by individuals and individual groups as research workers has been done and presented in the first chapter of the thesis.

The following hypotheses have been formulated to be tested in the present study:

(1) The structural changes on agricultural holdings have created impact on farm practices and cropping pattern.

(2) There exists appreciable difference in the intensity of input use and the level of output between consolidated and non-consolidated farms.

(3) The consolidated farms have higher level of net farm profits to those of non-consolidated farms.

(4) There exists a scope for increasing the net returns to the fixed farm resources of consolidated and non-consolidated farms through rational resource adjustments and changes in cropping pattern.

Methodology

Two stage stratified random sampling has been adopted for the present study. Two development blocks namely Mariahun and Machhalishahr adjoining each other were intentionally selected for the present study. In Mariahun block the work of consolidation was underway for quite a few years and in Machhalishahr block consolidation work has not yet started.

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The consolidated block has 105 villages These were arranged in ascending order of their consolidated area and were divided into three strata :—

(1) Villages where half of the consolidation work was done.

(2) Villages where consolidation work was completed from 50 to 75 per cent.

(3) Villages where the consolidation work was completed on 75 per cent and above area of the village.

The first group covered 45 villages, second 35 and 25 villages fell in the third group. One village from each group of consolidated block was selected randomly which accounted for a sample of 3 villages in Mariahun block. Similarly, a matching sample of 3 villages were selected randomly in non-consolidated block Machhalishahr after arranging in ascending order of their total area.

A list of farm holders in the sample villages of the consolidated block was prepared and were then arranged in ascending order of their cultivated area. These farms were stratified into three size groups viz., (i) upto 1 hectare; (ii) 1 to 2.5 hectares; and (iii) 2.5 hectares and above.

10 per cent of farms from each size group were selected randomly. Thus a sample of 45 farms were included in the sample distributed in three size groups according to the probability proportionate to the number in each size group. A matching sample of 45 farms from the non-consolidated block was also selected randomly.

The enquiry relates to the agricultural year 1977-78 (July 1 to June 30). The survey method was adopted for collecting the field data. The enquiry was conducted at different intervals in three rounds by interviewing the sample farmers. The farmers, were contacted in July 1977, December 1977 and April-May 1978. The secondary data have been obtained from block and district records.

Both tabular and regression analysis have been used for analysing the data. Based on the estimated regression coefficients, the marginal productivity of farm resources were worked out both on consolidated and non-consolidated farms.

Both the blocks Mariahun and Machhalishahr are adjoining to each other. The blocks are almost plain except the eroded areas of river Sai. Soils of the sample blocks vary from light loam to heavy clay. The soils, in general are fertile and grow a variety of crops.

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Main findings of the study are summarized in the following paragraphs.

There emerged a marked increase in the level of mechanization as a result of consolidation. More irrigation facilities and roads for access to farms have been developed on consolidated farms as compared to non-consolidated farms. Also, the number of plots per farm has gone down and the average size of plots has increased as a result of consolidation.

There has been a marked shift in the cropping pattern due to the development of irrigation facilities on consolidated farms. The acreage under less remunerative crops such as jowar, bajra, arhar barley, and gram has gone down and the land thus released is allocated to the high yielding varieties of more remunerative crops like paddy, wheat and sugarcane. Area under sunhemp has completely disappeared on consolidated farms. Also the area under current fallow has gone down and the cropping intensity has increased as a consequence of increased facilities of irrigation on consolidated farms.

Area under improved seeds as a single practice accounts for 12.64 and 11.37 per cent to the gross area sown on consolidated and non-consolidated farms, respectively. Area under fertilizers, implements and other practices on consolidated farms accounts for 18.95, 14.99 and 5.07 per cent respectively while the estimates for non-consolidated farms are 9.92, 10.79 and 3.37 per cent. Thus the hypothesis number one stating that "the structural changes on agricultural holdings have created impact on farm practices and cropping pattern" is accepted. Area under high yielding varieties of seeds increases with the increasing size of farms. Also an increasing trend in package of practices is observed with the size of farms and these are higher on consolidated farms than those of non-consolidated farms.

Quantity of chemical fertilizers per farm increases with the increasing size of farm while a negative and decreasing relationship is found on the basis of per hectare use of fertilizers. Application of fertilizers per hectare is found to be maximum in wheat followed by paddy on both categories of farms. The employment of human labour is also estimated to be higher for consolidated farms as compared to non-consolidated farms.

Estimates of costs of cultivation per hectare for all farms are worked out as Rs. 1240.82 and Rs. 1053.83 on consolidated and non-consolidated farms respectively. It decreases with the increasing size of farms.

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Yield of major crops per hectare of gross area sown are higher in case of consolidated farms as compared to those of non-consolidated farms. There has been an overall increase of 39.49 per cent on consolidated farms over non-consolidated ones. Thus the hypothesis number two stating that, "there exists appreciable difference in the intensity of input use and the level of output between consolidated and non-consolidated farms," is accepted. However, yield of all crops on both the categories of farms decline with the increasing size of farms.

The gross income per hectare for all farms on consolidated farms is worked out on Rs. 2171.51 and that on non-consolidated ones is Rs. 1590.79 recording an over all increase of 36.48 per cent on consolidated farms. It decreases as the size of farm increases in case of both categories of farms.

Net income per hectare for all farms on consolidated farms is worked out as Rs. 931.73 and that on non-consolidated ones is Rs. 936.96 recording an overall increase of 73.55 per cent on consolidated farms. Thus the hypothesis number three "stating that the consolidated farms have higher level of net farm profits to those of non-consolidated farms" is accepted.

Farm business income is worked out as Rs. 1415.64 per hectare for all farms on consolidated farms and Rs. 946.08 on non-consolidated farms. Again, there is an over all increase of 46.63 per cent in case of consolidated farms over non-consolidated farms.

Input-output ratios show a declining trend as the size of farm increases in case of all farms. Between consolidated and non-consolidated farms the figures of input-output ratios for major as well as all farms are higher in case of consolidated farms to those of non-consolidated farms in all size groups.

The Cobb-Douglas type of production function has been used to study the resource productivity and MVPs of the selected variables on both the categories of farms. Separate analysis for major crops like paddy and wheat and all farms has been made in the Chapter IV of the study.

In case of paddy sum of elasticities is less than unity indicating thereby a diminishing returns to the scale on both the categories of farms. The marginal value productivity on consolidated farms as compared to non-consolidated farms for the selected variables is higher in different size groups.

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For wheat the sum of elasticity is more than unity on consolidated farms indicating increasing returns to the scale, and it is less than unity on non-consolidated farms indicating diminishing returns to the scale. Marginal value productivity for the selected variables is higher on consolidated farms as compared to non-consolidated farms in different size groups.

Considering all farms together the regression coefficients for land and expenditure on seed, manure, fertilizer, are important variables on both the categories of farms. The sum of elasticities for both consolidated and non-consolidated farms are less than unity indicating diminishing returns to the scale for these variables. The marginal value productivity for all these variables is higher in case of consolidated farms. Thus the hypothesis number four stating that, "there exists a scope for increasing the net returns to the fixed farm resources of consolidated and non-consolidated farms through rational resource adjustments and changes in cropping pattern," holds good and is therefore accepted.

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AGRONOMY

CONTROL OF AQUATIC WEEDS

Hausila Prasad Singh Sup. : *Dr. S. N. Sharma*

Water is the most important resource of biosphere. Biologically, it constitutes a highly active ecosystem associating varied flora and fauna, dissolved plant nutrients and gases–chiefly oxygen. In an ecosystem, the intensity of aquatic flora is balanced through interaction effect of several physio-chemical and biological factors operating both within and outside the waterbody. Disturbance in such balance in ecosystem brings about rapid changes in the entire web of life inevitably leading to the rampant growth of aquatic flora as weeds many times. Aquatic weeds have always existed, but in recent years their effects have been magnified by man's more intensive use of natural waterbodies-modifying them into canals, dams, polluting them with farm and city waste waters, and introducing aggressive plant species into new locations. These plants, among the most prolific on earth, grow luxuriantly in the tropics and can be a serious hindrance to a nation's development efforts.

Role of plants in waterbodies is well recognised. It is only the plant that can transform and conserve solar energy into chemical energy, resulting into the production of biomass stimulating the production of variety of aquatic fauna. Nevertheless, aquatic weeds are equally problematic particularly in tropical and sub-tropical countries on account of increasing numbers of dams and irrigation projects coupled with warm water conducive for faster growth of aquatic plants.

In India, most of the large irrigation and hydro-electric projects and their associated dams, reservoirs and rivers have been rendered useless by intensive aquatic weeds infestation responsible for decreasing the water flow by 40 to 50 per cent. Over 140 species of aquatic weeds have been reported in varied ecological situations in this country. In addition, out of 8 lakh hec ares of freshwater available for pisciculture in India, about 40 per cent is rendered unsuitable for fish production because of invasion by aquatic weeds.

Navigation in internal waterways is also seriously hampered by the massive growth of aquatic plants. Subsistence farmers in the wet lowlands face annual disasters when rafts of aquatic weeds are floated

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over their rice paddies by floodwaters. As the floods recede, the weeds remain back and kill the rice crop. As the aquatic weeds spread, they transmit and foster many lethal diseases.

Herbicides are efficient and often preferred as effective tools for noxious vegetation control in many situations. They are quick acting agents that often have access to weeds, that are unapproachable by other methods. Their development, however, presents a number of unique problems, chiefly because of the multifacet uses of water. Herbicides used for the control of aquatic weeds must not cause appreciable mortality in a fish population and must be compatible with man's direct uses of water. Nevertheless, a suitable selection can be made from the available herbicides keeping in view the weed problem, the major water use and the effect of chemical on aquatic food.

In the light of the background knowledge available in this respect, an experiment was planned and conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during summer, monsoon and winter seasons of 1981-82 and 1982-83 with following objectives :

1. To study the effect of different herbicides on growth and chemical composition of aquatic weeds.
2. To study the effect of these herbicides on nitrogen, phosphorus and potassium removal by aquatic weeds.
3. To study the seasonal effect on efficacy of the herbicides in weed control.
4. To study the effect of the herbicides as also the different seasonal variations on water qualities.
5. To select suitable herbicides for specific weed situations as prevalent in farm ponds of this area.

An experiment was laid out with 3 herbicidal treatments and one control (without herbicide). For all practical purposes including the experimental methodology, sampling and statistical analysis procedure of Randomised Block Design were adopted. Experiment was laid out in four natural ponds of varying size with almost similar aquatic flora situated at Research Farm, Institute of Agricultural Sciences, Banaras Hindu University.

A survey was carried out to obtain an idea of aquatic weed flora of this region. Before laying down the experiment, important weed

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flora present in the selected farm ponds were identified. There were some emergent weeds (*Eleocharis plantaginea, Zizania aquatica, Paspalum scrobiculatum* and *Nymphaea stellata)* and floating weed *(Eichhornia crassipes)* present in the farm ponds.

The experiment was laid out in four farm ponds in randomised block design. Number of samples drawn (3) in each sampling has been taken as replication for statistical calculation. Except for the variation in size and quantity of water, all the ponds were almost identical in every respect.

The soil of all the experimental ponds was sandy clay loam having pH (6.55–6.90), high organic carbon (1.055–1.185 per cent), total nitrogen (0.083–0.090 per cent) and medium in available phosphorus as well as potassium.

The herbicides were applied in three different ponds at recommended doses in all the three seasons. Sodium salt of dalapon (80 per cent) @ 15.0 kg a.i., sodium salt of 2,4-D (80 per cent) @ 1.5 kg a. e. and paraquat (24 per cent) @ 1.0 litre a. i. ha^{-1} were applied on the vegetative canopy in the ponds in each season. One pond was kept as control (without herbicide) for comparison.

Morphological observations like weed population/m^2, number of upright shoots/m^2, fresh weight (g/m^2) and dry weight (g/m^2) were recorded at four stages (7, 28, 49 and 70 days after spraying). Chlorophyll 'a', 'b' and 'total' of leaves were also recorded at five successive stages (3, 7, 11, 30 and 60 days after spraying) of observation. Nitrogen, phosphorus and potassium content of weeds and their removal from ponds by them were worked out. Starch, reducing and non-reducing in weeds were also determined.

Apart from the weed characteristics, water was analysed at different intervals (before spraying and 7, 28, 49 and 70 days after spraying) for water temperature (C), specific conductivity (mmhos/cm at 25°C), pH, total alkalinity (ppm), dissolved oxygen (ppm) and free carbon dioxide (ppm). Persistency of different herbicides was also observed.

A composite soil sample from 0-30 cm bottom soil were collected before starting the experiment and also after completion of the experiment. It was analysed for nutrients status of pond soil with respect to organic carbon, pH, total nitrogen, available phosphorus and potassium.

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The results thus obtained, regarding weed and water characteristics during both the years projected an almost similar trend of response. The salient findings emanating therefrom, are summarised as under :

Weed population, number of upright shoots, fresh and dry weight of shoots/m^2 decreased drastically due to herbicidal treatments as compared to untreated control and maximum reduction was recorded at 49 days after treatment with aimost all the herbicides. Paraquat was most effective in checking weed growth followed by dalapon and 2,4-D.

Chlorophyll 'a', 'b' and 'total' in dominant emergent and floating weeds were reduced after herbicidal application. The maximum reduction was noticed either at 7 days or at 11 days stage.

The effect of seasonal variation was also highly pronounced on all the growth characters i. e. weed population, number of upright shoots, fresh and dry weight/m^2. Chlorophyll contents of dominant aquatic weeds also varied in different seasons. Summer season was found to be most suitable for aquatic weed control and herbicidal efficacy. However, all the growth characters showed improvement at last stage (70 days) in both the years.

The nitrogen, phosphorus and potassium content and their removal by weeds from ponds decreased significantly till 49 days stage following herbicidal application. Thereafter, a slight reversal of this process appeared to set in. The reduction of these chemical constituents in weeds was also affected by different seasons. The nutrient removal by weeds was minimum in summer.

Starch, reducing and non-reducing sugars in weeds were also reduced significantly by herbicides almost up to 49 days stage of observation. 2.4-D was found to be most effective herbicide in reducing these chemical constituents of weeds. Among the seasons, summer appeared to have most telling effect on the content of these carbohydrates in weeds.

Water qualities (water temperature, electrical conductivity, pH, total alkalinity, dissolved oxygen and free carbon dioxide) showed significant variation in all the three seasons, and stages were also found to be significant. The electrical conductivity, total alkalinity and free carbon dioxide were increased following herbicidal treatment till 28 days stage, and thereafter, a downward trend was observed. But, the trend was not the same in control pond. However, the pH

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values were lowered in treated ponds from first to last stage. Per contra, untreated pond showed slight increase in all the seasons. Dissolved oxygen was depleted considerably at 7 days stage but thereafter, an upward trend was noticed unitl it reached its peak. Conversely, the control pond showed slight improvement from the very beginning but the values remained quite low as compared to treated ponds. Paraquat was found to be the most useful herbicide as far as water quality is concerned.

The herbicide residue was drastically low in water after some time. Paraquat was first to disappear followed by dalapon and 2,4-D respectively in all the three seasons. However, the disintegration of weedicides was slow in winter as compared to summer and monsoon seasons.

On the basis of experimental findings, the following conclusions were drawn :

1. The growth of aquatic weeds was severely impeded by all the herbicidal treatments.
2. Nitrogen, phosphorus and potassium content in weed and their depletion from ponds were restricted by use of herbicides
3. Certain characteristics of pond water can be improved by reducing the weed population through herbicidal application.
4. Paraquat at 1.0 litre a. i./ha was most effective for controlling the weeds in ponds.
5. Herbicidal treatments were most effective in summer season.

Recommendations

As a consequence of the conclusions of the present investigation the following recommendations may be made :

1. Heribicides may be safely employed for controlling aquatic weeds.
2. Paraquat @ 1.0 litre a. i. ha^{-1} may be safely use for effective control of aquatic weeds in general.
3. Herbicidal treatments shall be more effective when used in summer season.

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STUDIES ON NITROGEN ECONOMY IN RICE THROUGH SUMMER MUNG AS AFFECTED BY NITROGEN AND RHIZOBIUM

Kailash Prasad Singh Sup. : *Dr. Kalyan Singh*

The present investigation entitled "Studies on nitrogen economy in rice through summer mung as affected by nitrogen and *Rhizobium*" was carried out at the Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the year 1981 and 1982.

Field experiments on summer mung crop having six treatment combinations of three seeding time treatments (*Rhizobium* inoculation, 20 kg N/ha and control) and two cropping treatments (summer mung harvested as straw and green manuring after two pickings) were laid out in a randomized block design and were replicated thrice. The treatments were allocated randomly in each block of the design. Rice variety Pusa-33 was raised as a succeeding crop having four levels of nitrogen (0, 40, 80 and 120 kg N/ha). Thus, the each plot of summer mung was divided into four sub-plots making 24 treatment combinations. Treatments were again randomly allocated as sub-plot treatments in all the six main plots of summer mung making it a simple split plot design. The experimental soil was sandy clay loam in texture having pH 7.1, low in nitrogen and organic carbon contents and medium in available phosphorus as well as potassium. A uniform basal dose of 60 kg P_2O_5/ha and 30 kg K_2O/ha in summer mung were applied as single super phosphate and muriate of potash, respectively. Nitrogen was applied as per treatment using urea as a source of fertilizer. Whole amount of nitrogen as per treatment was applied at seeding time in summer mung. However, in rice nitrogen application was performed as per treatment in split doses viz., half at transplanting and the remaining half was applied in two equal splits half at tillering and half at panicle initiation stage.

Besides, grain and straw yields of summer mung, number of observations on growth characters as well as yield and yield attributes (nodule dry weight, dry weight per plant and leghaemoglobin content of fresh nodules, pod number per plant, grains per pod, 1,000 grain weight, harvest index and crude protein content) were recorded. Data on growth characters as well as yield and yield attributes of succeeding rice crop (plant height, tillers per hill, dry matter accumulation per hill, panicle length, panicle weight, filled

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grains per panicle, unfilled grains per panicle, 1,000 grain weight, harvest index and crude protein content) were also recorded. The nitrogen, phosphorus and potassium contents at different stages of rice crop and their total uptake by grain and straw of summer mung as well as by rice crop were also worked out. The composite samples from 0-30 cm soil layer before seeding and after the crops harvest were analysed to have the idea of nutrient status of the soil with respect to total nitrogen, available nitrogen, phosphorus and potassium in both the years. These composite samples were also analysed for some single value physical constrants, viz., bulk density and water stable soil aggregates after the completion of two year's summer mung-rice sequence. Nitrogen, phosphorus and potassium balance after crop harvest was also worked out. The salient features of the results obtained are summarised below.

In general, the effect of nitrogen as well as *Rhizobium* culture were similar with respect to all the observations under study in summer mung either summer mung was harvested as grain and straw or grain and green manuring after two pickings.

Rhizobium culture significantly increased the growth characters, leghaemoglobin content, yield attributes, grain and straw yields of summer mung and led to a higher nitrogen, phosphorus and potassium uptake by summer mung. Total protein content was also increased with the use of *Rhizobium* culture.

Cropping treatments showed significant residual effect on succeeding rice crop and the plots where summer mung plants were green manured after two pickings had significantly higher values of all the growth characters, yield attributes, grain and straw yields of rice and led to higher uptake of nitrogen, phosphorus and potassium by the rice crop.

Fertility status of the soil in respect to total nitrogen, available nitrogen, phosphorus and potassium was also favourably improved by green manuring of summer mung plants after two pickings even after the rice harvest.

Among the seeding time treatments tried, *Rhizobium* culture significantly increased the growth characters, yield attributes, grain and straw yields of succeeding rice crop and led to higher nitrogen, phosphorus and potassium uptake. Total protein content in rice grain was also increased with the use of *Rhizobium* culture.

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Fertility status of the soil in respect of total nitrogen available nitrogen, phosphorus and potassium was also improved by *Rhizobium* culture after the rice harvest.

Application of 120 kg N/ha to rice significantly increased plant height, number of tillers per plant and dry matter accumulation per hill. Application of 120 kg N/ha significantly increased the panicle length, panicle weight, number of filled grains per panicle, number of unfilled grains per panicle and 1,000 grain weight as well as grain and straw yields. Pooled analysis of grain yield data for two years also showed similar trend.

On the basis of response curve, the most profitable rate of nitrogen application was worked out to be 82.8 kg and 70.8 kg N/ha for both the treatments, summer mung harvested as grain and straw and summer mung plants green manured after two pickings, respectively.

Application of nitrogen significantly increased the crude protein content and the maximum protein yield was obtained with 120 kg N/ha during both the years. Nitrogen, phosphorus and potassium content in rice plant at different growth stages as well as their total uptake in grain and straw also increased significantly with increasing levels of nitrogen and the maximum uptake of these nutrients was associated with the highest level of 120 kg N/ha in both the years.

Nitrogen application favourably improved the soil nutrient status with respect to total as well as available nitrogen. Increasing the levels of nitrogen application, however, decreased the available phosphorus and potassium status of the soil after the rice harvest during both the years of experimentation.

REQUIREMENT OF NITROGEN, PHOSPHORUS AND POTASSIUM IN RICE-WHEAT ROTATION

Shashi Shekhar Singh Sup : *Dr. Mahatim Singh*

The present investigation entitled "Requirement of Nitrogen, Phosphorus and Potassium in Rice-Wheat Rotation" was carried out at the Research Farm of the Department of Agronomy, Banaras Hindu University, Varanasi, during the kharif seasons of 1977 and 1978 on rice and wheat as succeeding crop in rabi seasons during 1977-78 and

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1978-79 with a view to study and assess the requirement of nitrogen, phosphorus and potassium of rice and wheat crops in a continuous rice-wheat rotation.

The soil of the experimental field was sandy loam having low status of nitrogen and medium status of phosphorus and potassium. The experiment was laid out and conducted in $3^2 \times 2$ factorial partially confounded design. The treatment comprised of three levels of nitrogen (40, 80 and 120 kg/ha), three levels of phosphorus (0, 40 and 80 kg P_2O_5/ha and two levels of potassium (0 and 40 kg K_2O/h) in addition to one absolute control ($N_0P_0K_0$) in each block. The eighteen treatment combinations along with the absolute control were replicated four times. Urea, single superphosphate and muriate of potash were used as sources of fertilizers in both the crops. Half of the nitrogen and the entire quantities of phosphours and potassium were applied at the time of transplanting of rice and sowing of wheat; the remaining nitrogen was top dressed in two equal amounts at the interval of one month after transplanting in the case of rice and after sowing in the case of wheat. Rice was transplanted on 28th and 15th July, while wheat was sown on 22nd and 27th November, respectively in two years. Transplanting of rice utilizing 25 days old seedlings was done after puddling, while wheat was sown in the field prepared after presowing irrigation to maintain uniform moisture at the start of experiment. In both the years the seed rate was maintained at 100 kg/ha. Jaya, the most popular variety of rice and HD (M) 1553 variety of wheat were used in this study. All the standard measures of agronomic package of practices were performed from time to time upto maturity of the crop.

To study the nitrogen, phosphorus and potassium requirements of rice and wheat crops in rice-wheat rotation growth observations, viz., height of the plant and number of total tillers per m^2 were recorded one week prior to the harvest of the crop. Yield and yield attributes, viz., number of effective tillers per m^2, length of panicle in rice and ear in wheat, total number of grains per ear, filled grains per panicle in rice and per ear in wheat, sterile grains per panicle, thousand grains weight and yield of grain and straw per hectare were determined after the harvest of the crop. Grain yield response and magnitude of response at various levels of nitrogen, phosphorus and potassium of rice and wheat were worked out. Economics of rice and wheat cultivation was also worked out taking mean values obtained from the data of the two years. The plant samples (grain and straw of rice and wheat) obtained at harvest were chemically analysed for determining total nitrogen, phosphorus and potassium (kg/ha) were calculated accordingly. The

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soils of the experimental plots were sampled after completion of each crop cycle (Rice-wheat) and were analysed for total nitrogen, available phosphorus and available potassium. An attempt was also made in addition to present an approximate balance sheet of total nitrogen, available phosphorus and available potassium after each crop cycle (Rice-wheat) during both the years.

The salient features of the research findings and broad conclusions derived from them are given below :

Growth Characters

Every additional dose of nitrogen increased the plant height of rice and wheat significantly upto 120 kg N/ha over the control. However, in wheat 80 and 120 kg N/ha were found at par. Similarly, 4o, and 80 kg P_2O_5 recorded significant differences over the control but were at par among themselves. No significant effect of potassium was found.

Significant increase in total number of tillers/m^2 was found upto 120 kg N/ha over the control in rice and wheat. But in rice plant significant differences between 120 and 80 kg N/ha were not noticed. Applicatian of 80 kg P_2O_5/ha recorded significant increase in total number of tillers/m^2 over the control in both the crops. Minor increase in total number of tillers due to potassium application was found.

Yield Attributes

Number of effective tillers increased significantly with each level of nitrogen over the control in both the crops. However, during the first year in rice and in the second year in wheat 80 and 120 kg N/ha was found at par. Application of 40 and 80 kg P_2O_5/ha recorded significantly higher number of effective tillers over the control plot, but were found at par. This trend was noted in rice in both the years and in wheat only during the second year. The first year of wheat crop recorded significant differences at all the three levels of phosphorus. No effect of potassium was observed.

Length of panicle in rice and ear in wheat measured significant difference with each increment in the levels of nitrogen over the control. But in rice only 80 and 120 kg N/ha were found at par. None of the phosphorus levels were found significantly superior in rice crop. On the other hand, ear length increased significantly upto 80 kg P_2O_5/ha in both the years. In the second year such a difference was noted only between the control and 80 kg P_2O_5/ha. Potassium had no significant effect either on panicle or ear length.

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Each level of nitrogen significantly increased the number of filled grains per panicle in rice and per ear in wheat upto 120 kg N/ha. But 80 and 120 kg N/ha was found at par. At the control and 40 kg N/ha level, higher number of fertile grains/panicle were observed in the first year while it was more during the second year at 80 and 120 kg N/ha. In the first year number of filled grains per ear at 40 and 80 kg N/ha were at par. In the second year 40 kg N and the control plot and 80 and 120 kg N/ha were at par. Potassium particularly increased the number of filled grains per panicle in rice and per ear in wheat over the control.

Higher number of sterile grains/panicle was found with the increasing levels of nitrogen during both the years. On the other hand, application of phosphorus and potassium levels reduced the sterility.

Weight of thousand grains of rice and wheat increased with increasing levels of nitrogen and phosphorus. In case of rice at the control and 40 kg N/ha it was higher in the first year, while at 80 and 120 kg N/ha it was found higher in the second year. Significant difference between the control and 120 kg N/ha was found in the second year of wheat crop. Application of 40 and 80 kg P_2O_5/ha recorded higher test weight in the second year in rice crop. Potassium had no effect on thousand grain weight in either of t e crops.

Grain Yield

Nitrogen application consistently and significantly increased the yield of grain over its preceding nitrogen level upto 80 kg N/ha in rice and upto 120 kg N/ha in wheat. In case of rice, application of 40 and 80 kg P_2O_5/ha recorded significant superiority over the control, but both were found at par. While in wheat crop significant differences were observed only between the control and 80 kg P_2O_5/ha. Application of 40 kg K_2O/ha recorded significant increase in wheat grain yield only during the second year. But effect of potassium along with lower and medium level of nitrogen ($N_{40}P_0K_{40}$ and $N_{80}P_0K_{40}$) were found quite promising during both the years in rice crop. In case of wheat also addition of potassium along with 80 and 120 kg N (i. e., $N_{80}P_{80}K_{40}$, $N_{120}P_0K_{40}$ and $N_{120}P_{80}K_{40}$) recorded higher grain yield over nitrogen alone.

Straw Yield

Each increment of nitrogen recorded significant increase in straw yield of rice and wheat during both the years. In case of rice, phosphorus levels gave higher straw with their increasing levels, but none

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of them was found significant. On the other hand, 80 kg P_2O_5/ha recorded significantly higher straw yield over the control in case of wheat straw. Differences between 40 and 80 kg P_2O_5/ha were non-significant. Increase in straw yields due to potassium application was rather marginal.

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Yield Response

Input-output relationship between levels of nitrogen and yield of rice and wheat grain showed that the response followed the law of diminishing return. Maximum rate of nitrogen for rice was calculated to be 113.20, 112.40 and 115.80 kg N/ha and most profitable rate 88.40, 84.0 and 78.0 kg N/ha, respectively during the first and the second year as well as with the mean of two years. In case of wheat crop, maximum rate of nitrogen was found to be 140 kg N/ha and most profitable rate 123.60 kg N/ha during the second year. In the first year both were found more than the highest level of nitrogen tried, i. e., 120 kg N/ha.

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Magnitude of Grain Yield Response

The magnitude of grain yield response increased with increasing levels of nitrogen in (rice and wheat crop during both the years of experimentation. In case of rise, the response increased upto 80 kg P_2O_5/ha in the first year and only upto 40 kg P_2O_5/ha during the second year. In wheat crop response increased with increasing levels of phosphorus upto 80 kg P_2O_5/ ha during both the years. Response over immediately previous nitrogen and phosphorus levels showed decreasing trend with increasing levels of nitrogen and phosphorus. Response at 40 kg K_2O/ha over the control was obtained only during the second year of wheat crop. Rice crop in the first year recorded very small increase in grain yield due to potassium fertilization.

Economics of Treatments

Net profit and additional profit over the control increased with increasing levels of nitrogen and the highest profits were obtained at 120 kg N/ha in both the crops. But the application of 120 kg N/ha over 80 kg nitrogen marginally increased the profit in rice. While in wheat crop it was 120 kg nitrogen which recorded quite higher profit over 80 kg N/ha. In case of phosphatic fertilization, profits were mostly in favour of 40 kg P_2O_5/ha in case of rice crop and 80 kg P_2O_5/ ha in wheat. The maximum profit was recorded with 80 kg P_2O_5/ha. Application of 40 kg K_2O/ha gave small profit in case of wheat crop only.

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Response of Nutrients

Response of both nitrogen and phosphorus fertilizers in producing grain per kg of nutrient applied was found to be maximum at their lower levels and as the level of nitrogen and phosphorus increased their response of producing grain per kg of nutrient applied decreased. Response due to potassium fertilization was negligible in rice, but was apparent in wheat.

Nutrient Content

Nitrogen content was found increasing with increasing levels of nitrogen and phosphorus. On the other hand, potassium had only small effect in rice and wheat during both the years. Uptake of nitrogen increased with levels of nitrogen, phosphorus and potassium due to increase in biological yield.

Phosphorus content in rice and wheat plant was found to be the maximum in the control plots and as the level of nitrogen increased phosphorus content decreased. But uptake data showed increasing trend with increasing levels of nitrogen. Phosphorus levels (40 and 80 kg P_2O_5/ha) improved phosphorus content of rice and wheat grain and straw. The uptaken of phosphorus was found increasing with increase in the levels of phosphorus fertilizers. The application of potassium also improved the content of phosphorus.

Different levels of nitrogen, phosphorus and potassium caused appreciable improvement in potassium content of rice and wheat plants. Such an effect was more pronounced due to potassium applicatfon. Higher uptake of potassium was recorded at higher levels of nitrogen, Phosphorus and potassium in comparison to their lower levels.

Balance Sheet

There was greater depletion of total nitrogen in soil with increasing levels of nitrogen fertilizers during both the years. An increasing loss of available phosphorus was also experienced at all the levels of phosphorus applied excluding the control, where there was a positive gain. Balance of available potassium in soil was found positive after each crop cycle, which showed a decreasing trend in the second year.

Conclusions

The following broad conclusions may be drawn on the basis of the results of the present investigations :

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(1) Growth and yield attributes increased with increasing levels of nitrogen and phosphorus. Potassium had very minor effect. However, it increased the number of filled grains and thousand grain weight appreciably.

(2) Grain yield increased with increasing levels of nitrogen and 80 kg N/ha in rice and 120 kg N/ha in wheat increased the yield significantly. Similarly, 40 kg P_2O_5/ha in rice and 80 kg P_2O_5/ha in wheat crop gave higher yield over the other levels of phosphorus. Significant effect of potassium was found only in wheat crop during the second year.

Effect of potassium was found quite promising at 40 kg ($N_{40}P_0K_{40}$) and 80 kg N/ha ($N_{80}P_0K_{40}$) in rice. In case of wheat also at 80 and 120 kg N/ha with or without phosphorus (i. e., $N_{80}P_{80}K_{40}$, $N_{120}P_0K_{40}$ and $N_{120}P_{80}K_{40}$) increase in wheat grain yield was quite remarkable.

(3) Maximum rate of nitrogen for rice was calculated to be 113.20 and 112.40 kg N/ha in the first and the second year, respectively and the most profitable rate was 88.40 kg in the first year and 84 kg N/ha in the second year. On the other hand, the maximum rate of nitrogen was 140 kg/ha and most profitable rate was 123.60 kg N/ha in the second year in wheat crop During the first year both were found quite high.

(4) Magnitude of grain yield response increased with increasing levels of nitrogen. In case of phosphorus, response increased upto 80 kg P_2O_5/ha in the first year, but upto 40 kg P_2O_5/ha in the second year. Wheat crop responded upto 80 kg P_2O_5/ha in both the years. The response of nitrogen and phosphorus over its immediate previous level decreased with increasing levels of nitrogen and phosphorus. Response of potassium was noticed only during the second year of wheat crop.

(5) Net profit and additional profit was found favourable only upto 80 kg nitrogen and 40 kg phosphorus per hectare in rice. While in wheat it was found profitable at 120 kg nitrogen and 80 kg phosphorus per hectare. No appreciable gain due to potassium application was noticed in rice, although it gave minor profit in wheat.

(6) Higher response of nitrogen, phosphorus and potassium in producing grain per kg of nutrient applied was found at their lower level of application and as their level increased response decreased.

(7) Higher content of nitrogen, phosphorus and potassium was found with increasing levels of nitrogen, phosphorus and potassium,

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respectively. Their uptake increased with increasing levels of nitrogen, phosphorus and potassium fertilizers.

(8) Total nitrogen decreased in soil with each crop cycle. Reduction was sharp at the higher levels of nitrogen fertilization. Except the control plot, available phosphorus decreased in all the phosphorus treated plots. Potassium had positive balance but it showed a decreasing trend after each crop cycle.

Recommendation

Keeping in view all the above mentioned facts 80 kg N and 40 kg K_2O/ha was found economical for rice and 120 kg N, 80 kg P_2O_5 and 40 kg K_2O/ha for wheat. Application of phosphorus in rice cannot be recommended keeping in view the fact that wheat crop cannot utilize all the added phosphorus and leaves phosphorus in the soil which will be available for coming rice crop. Rice crop is also known to be the best utiliser of native phosphorus in comparison to wheat and can exploit phosphorus fractions of soil very easily. However, soil test for available phosphorus after each crop cycle (rice-wheat) will be essential and if soil shows any sign of reduction in status of available phosphorus application of phosphorus at the rate of 40 kg P_2O_5/ha along with $N_{120}K_{40}$ will become essential for higher yield and sustaining soil productivity.

EFFECT OF GAMMA IRRADIATION AND CYCOCEL ON AGRONOMIC AND PHYSIOLOGICAL ASPECTS OF BARLEY (*Hordeum vulgare* L.) UNDER RAINFED CONDITION

Venkateswarlu Munukutla Sup. : *Dr. N. M. Misra*

The research project entitled "Effect of gamma-irradiation and Cycocel on Agronomic and Physiological aspects of barley under rainfed condition", was undertaken with the following objectives :

(i) To induce drought tolerance through gamma-irradiation; and

(ii) to induce drought tolerance through use of Cycocel as seed treatment and foliar spray.

Under this project, the following three field trials were conducted for two consecutive years at the Agronomic research farm, B. H. U., Varanasi, during the *Rabi* seasons of 1978-79 and 1979-80 under rainfed condition.

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Field Trial No. 1

"Effect of gamma-irradiation on agronomic and physiological aspects of barley".

In this Field Trial 1000 g of barley seeds were packed in polyethylene bags specially made for the purpose and irradiated with ^{60}Co source at the gamma-irradiation cell of Genetics Division of I. A. R. I. in requisite doses. The gamma-irradiation doses were as follows :

0 Kr (control), 2 Kr, 4 Kr, 6 Kr, 8 Kr, 10 Kr, 12 Kr, 14 Kr, 16 Kr, 18 Kr and 20 Kr.

(Kr.) refers to ki lorad, a unit of measurement of ionizing radiation. The total number of treatments including control i. e. 0 Kr was 11. These eleven treatments were replicated thrice in R. B. D., thus making the total number of plots 33. The net plot size was $3.5 \times 4.0 = 14$ sq. meters. Barley variety (Ratna was selected as experimental material as it is recommended for N. E. tracts of U. P.) in all the three experiments.

Field Trial No. 2 (A)

"Effect of Cycocel as seed treatment on agronomic and physiological aspects of barley".

In this trial Cycocel was applied as seed treatment in different concentrations. The concentrations were 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm. A distilled water treatment and a control were also included in both the experiments thus, making 6 treatments.

Cycocel solution in requisite concentrations were prepared and 1000 g of seeds were soaked in the respective solutions on the basis of 60% seed weight for 24 hours with continuous stirring. After that the seeds were air dried till the original weight was obtained and the seeds were kept ready for sowing.

Field Trial No. 2 (B)

Cycocel was applied as foliar spray at 21 days after sowing in the same concentrations along with a control and sitilled water spray. Prior to spraying cycocel in respective concentrations i. e. 500 ppm, 1000 ppm, 1500 ppm and 2000 ppm was prepared and the solution was sprayed @ 800 liters per hectare basis at 11°, clock after ensuring the evaporation of dew. Teepol @ 0.01% was added as a sticking agent. Distilled water @ 800 litres per hectare was sprayed.

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These 6 treatments were replicated thrice in R. B. D. thus, making 18 plots in each of the experiments. The net plot size was kept the same in all the trials for both the years and the experiments were conducted on the same site.

A basal dose of 60 Kg. of nitrogen through urea, 30 Kg of phosphorous in the form of single super phosphate and 30 Kg of potash as murate of potash was drilled in furrows along with the seed.

From the above field trials the following inferences may be drawn.

Effect of Seed Irradiation with Gamma Rays

The maximum effect of irradiation was observed on plant height. The results reveal that, after a threshold level, plant height was reduced with an increase in irradiation dose. The lower doses i. e., 2 Kr to 8 Kr. increased the plant height; but the higher doses reduced the plant height successively. The increase in plant height under lower doses may be due to the radio-stimulative effect ; while the reduction in plant height under higher doses may be due to the deleterious effects of higher doses. The radio stimulative effect of a medium dose of 6 Kr enhanced the tiller production and thereby the leaf number was increased. This increased leaf number increased the total photosynthetic area which led to formation of greater photosynthates and thus the plants showed higher shoot dry matter. Further, it was observed that the medium dose of 6 Kr led to a decrease in transpiration rate even-though there was an increase in number of stomata; but these were associated with smaller aperture size. All these attributes cumulatively resulted in an efficient and more economical use of soil-moisture. As a result of the higher water balance in the tissues, the plants under this treatment were able to produce more ear bearing tillers by reducing the tiller mortality at maturity. The increased water balance also helped in more seedsetting by increasing pollen viability by which the grains per ear were incresed. The proliferate root growth under this treatment helped more translocation of Nitrogen towards the grain at maturity by which the protein content was increased. The next best result was given by 4 Kr and 2 Kr, while higher doses of radiation i. e., from 12 Kr to 20 Kr, showed a depressing effect on all these attributes due to their deleterious effect. 6 Kr and 4 Kr on an average increased the grain and straw yields as compared to control and other treatments. Thus, it may be postulated that the medium dose of 6 Kr increased the drought tolerance capacity in barley plants which is the most desired character for the cultivation of barley under dryland conditions.

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Effect of Cycocel as Seed and Foliar Spray Treatment

From field trial No. 2 (A) it is evident that the effect of pre-sowing seed treatment with cycocel, depended more on the prevailing weather conditions. During the year 1978-79 the rainfall was 78 mm and during 1979-80 it was 58 mm. Although the rainfall in the first year was more as compared to second year, most of this rain was received after the crop reached maturity; whereas in the second year 73% of the rainfall was received during the crown, root limitation stage and afterwards the rainfall was well distributed, and the crop suffered very little stress.

Cycocel in higher concentration i. e., 1500 ppm and 2000 ppm produced the higher grain and straw yields, only under relatively dry conditions prevailing during the earlier part of the growth period in 1978-79, whereas in 1979-80 cycocel treatment did not produce any significant increase in grain and straw yields. Thus, it may be concluded that the effectiveness of cycocel is higher under dry conditions rather than under conditions of adequate moisture. The increase in the yield in first year was perhaps due to increased number of tillers which increased the green leaf number, and hence the increased photosynthetic area. This increase, in turn, increased the shoot dry matter accumulation. Further, it was noted that the plants treated with higher doses of cycocel showed an increase in chlorophyll content and relative turgidity as a result of reduced transpiration rate due to increased number of stomata with reduced aperture. These attributes cumulatively increased the water balance in tissues, enhanced photosynthetic activity and reduced tiller mortality. Further, the treatment with cycocel might have increased the water balance in tissues, enhanced photosynthetic activity and reduced tiller mortality. Further, the treatment with cycocel might have increased the pollen viability leading to more grain setting per spikelet and per ear. The proliferate root growth helped the plants to translocate more nitrogen to the grain by which the protein percent of grain increased. In the second year the effect of the chemical persisted until the 60th day after which the effect disappeared due to higher water balance within the plant due to the well distributed rainfall. However, at maturity of the crop, the effect of cycocel disappeared bringing insignificant increase in grain and straw yields. Thus, it is apparent that the lasting effect of cycocel was more pronounced under dry conditions than under the conditions of sufficient moisture.

All these findings indicate that the pre-sowing seed treatment

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with cycocel in higher concentrations imparts drought tolerance to barley plants bestowing beneficial effects only under dry conditions.

Cycocel as foliar spray (single application) did not show any beneficial effect on barley under any weather conditions.

Seeds soaked in distilled water, or foliar spray of distilled water did not show any significant effect in both the years.

Conclusion

From the foregoing results of the three field trials the following conclusions may be drawn :

1. Seed irradiation with lower doses (2 Kr to 8 Kr, especially 6 Kr) imparted drought tolerance and brought about radio-stimulative effect on plant growth and development. Thus, it increased dry matter accumulation and also showed beneficial effect on yield attributes, resulting in higher grain and straw yields than control.
2. Seed irradiation with higher doses (12 Kr to 20 Kr) showed a deleterious effect not only on plant growth but also on physiological characters such as chlorophyll content and relative turgidity, and this resulted in lower grain yields than control.
3. Out of all the irradiation doses, 6 Kr was found to be an optimal dose with regard to yield and yield attributes, and physiological characters. It also imparted more drought tolerance capacity by maintaining a high water balance in the tissues which might have led to the survival of more ear bearing tillers and higher seed setting.
4. Relative turgidity was found to be the most reliable, quick and convenient physiological test for field measurement of the degree of drought tolerance capacity of plants.
5. Pre-sowing seed treatment with lower concentrations of cycocel does not have any beneficial effect on grain yield under dry land conditions. However, higher concentrations of cycocel i e., 1500 ppm to 2000 ppm recorded higher grain yields than control, only under relatively dry conditions, presumably by maintaining a higher water balance. Thus, it may be stated that the beneficial effects of cycocel are dependent on weather conditions which prevail during the crop growth period.

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6. Foliar spray of cycocel (single application) did not show any effect in improving the yield of barley under adequate or inadequate rainfall conditions.

7. Pre-soaking seed treatment through water or its foliar spray also did not show any useful effect on barley growing under rainfed condition.

8. Seed treatment with cycocel (1500 ppm to 2000 ppm) may be used as a safeguard against unpredictable weather conditions, especially when barley is grown under rainfed condition.

9. Thus, for increasing the barley production for getting higher returns in dryland farming areas, it may be recommended that seeds be treated with cycocel @ 1500 ppm or 2000 ppm or be irradiated with 6 Kr gamma-rays before *sowing* for improving the crop yields under dry land conditions.

EFFECT OF SOIL SUBMERGENCE ON GROWTH AND YIELD OF BLACK GRAM AND GREEN GRAM UNDER DIFFERENT METHODS OF SEEDING

Satya Prakash Sharma Sup. : *Dr. Kalyan Singh*

Soil moisture supply is one of the important factors affecting crop production. An adequate supply permits better utilization of other production factors leading to increased yield of crops per unit area and time. Both deficient and excess water present in the soil affect adversely the availability of water to plants and excessive conditions lead to complete failure.

A large area in the world and about 6 million hectares in India fall in the category of waterlogged soils. In addition, there are drainage problems in many localised areas within the category along the coastal line due to periodic in-gress of sea water during high tides.

Waterlogging has become a problem of paramount importance with the introduction of irrigation projects in recent years. The main factors that contribute to waterlogging are rainfall resulting the stagnation of water over extensive areas, seepage from unlined canals in high bank reaches and in tracts of fissured rocks, flooding by rivers, over

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irrigation and faulty rotation of crops, blocking of natural drainage system, abandoning percolation wells and subterranean obstructions.

Among the crops, pulses as a group are susceptible to water-logging. These crops have an important role in the human dietary in India because the majority of the population is vegetarian. Among the *kharif* pulses at present green gram and black gram are becoming more and more popular because of availability of short duration varieties which can be grown more than one season and hence can be fitted into sequential cropping and inrercropping sequences to maximise and economise production per unit area, per unit time and per unit water available.

On the other hand, these crops have on an average, very poor yieid per hectare. On analysis of the causes for low productivity of *kharif* pulses, one may come to the conclusion that the important factors affecting the yield are sowing date, fertilizers, diseases, pest and the last but not the least is the water management. Excess water not only affects adversely the physiological functions of the plants but also hinders in almost all the agronomic manipulations required for optimising the yield of these crops. Taking these factors in account the above area of research has been selected.

Though extensive work has been done to understand factors influencing the growth and yield of crop plants under deficient soil moisture conditions but the effect of short duration soil submergence or waterlogging have not been studied in detail. The past research efforts were mainly directed towards understanding the physiological causes responsible for low productivity of crop plants and the mechanism of adaptation to waterlogged conditions. However, field studies on the influence of soil submergence on growth and yield of black gram and green gram under different methods of seeding which can provide insight for developing water management technology under excess water conditions are particularly lacking. Keeping these points in view the present investigation entitled "Effect of soil submergence on growth and yield of black gram and green gram under different methods of seeding" was carried out at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* seasons of 1980 and 1981 with the following objectives :

(1) To evaluate the influence of soil snbmergence on growth and nodulation of black gram and green gram.

(2) To study the effect of soil submergence on grain and straw yields of black gram and green gram.

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(3) To determine the effect of soil submergence on nitrogen, phosphorus and potassium uptake by black gram and green gram.

(4) To work out the suitable method of seeding for economising crop production of grain legumes under temporary soil submergence.

Two separate experiments one each on black gram (var. T 9) and green gram (var. Pusa Baisakhi) with six soil submergence treatments and one additional unflooded control to ascertain the comparative influence of soil submergence under two methods of seeding (ridge and flat) were laid out in a randomized block design and were replicated thrice. The soil submergence treatment comprised of 3 durations of waterlogging viz., 24 hr, 48 hr and 72 hr imposed at two stages of crop growth, namely, seedling and flower initiation stages. Water was applied twice a day to maintain the soil water content at or above the saturation level through irrigations to the required plots keeping in view that bund did not breach. Water was drained from the plots in which waterlogging was not desired. The experimental soil was sandy clay loam in texture having pH 7.3, low in nitrogen and organic carbon contents and medium in available phosphorus as well as potassium. A uniform dose of N, P_2O_5 and K_2O at the rate of 20 kg, 60 kg and 40 kg/ha in the form of urea, single superphosphate and muriate of potash was applied at sowing time.

Similar experiments were also conducted in pots under controlled conditions except the methods of seeding.

Besides, grain and straw yields of legumes, a number of observations on growth characters (dry matter accumulation per plant, dry weight of nodules per plant, chlorophyll content of leaves) were recorded during waterlogging treatment and one week after withdrawal of treatments at both the stages of crop growth and yield and yield attributes viz., number of nodes and fruiting nodes per plant number of grains per pod, 1,000 grain weight and grain weight per plant were recorded. Nitrogen, phosphorus and potassium up take by grain and straw of legumes were also worked out.

The results obtained for both black gram and green gram were practically similar in nature and hence, the salient finding emanating for both the crops are presented in this section.

Dry matter accumulation per plant, dry weight of nodules per plant and chlorophyll content of leaves decreased considerably due to

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soil submergence at both the stages of crop growth as compared to unflooded control and the maximum reduction was observed at seedling stage than flower initiation stage of crop growth.

Duration of waterlogging also affected all the growth characters i. e., dry matter accumulation per plant, dry weight of nodules per plant and chlorophyll contents and increase in the duration of waterlogging from 24 hr to 72 hr decreassed the values of all the growth characters.

The rate of recovery after one week withdrawal of waterlogging treatments were more at seedling stage of crop growth with the longest duration of waterlogging. However, the actual percentage values achieved were always lower than the preceding treatment.

The number of total and fruiting nodes per plant though were affected by waterlogging treatments as compared to control but did not follow any particular trend.

Number of pods per plant, number of grains per pod as well as grain weight per plant were higher due to soil submergence at flower initiation stage of crop growth whereas the test weight of grains decreased significantly due to soil submergence at flower initiation stage as compared to seedling stage.

Duration of waterlogging significantly affected all the yield attributing characters and the maximum values of all the yield attributing characters were recorded with shortest duration of waterlogging i. e., 24 hr.

The highest grain straw yields of both black gram and green gram were recorded due to soil submergence at flower initiation stage and it was significantly superior to seedling stage in this respect. Pooled analysis of grain yield data for two years also showed similar trend.

Duration of waterlogging also significantly affected grain and straw yields and increase in the duration of warerlogging from 24 hr to 72 hr decreased the grain and straw yields. Thus the maximum grain and straw yields were observed with shortest duration of waterlogging during both the years. Pooled analysis of grain yield data also showed similar pattern.

Nitrogen, phosphorus and potassium contents in plants decreased markedly with waterlogging and so was the total uptake of these nutrients by the crops. Relatively nitrogen content decreased more at seedling stage whereas phosphorus and potassium declined at flower initiation stage. The variation in decrease as well as recovery were higher in case of nitrogen followed by phosphorus and potassium.

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Among the methods of seeding, ridge method of seedling had significantly higher values of all the growth characters, chlorophyll content, yield attributes and grain and straw yields of legumes and these together led to higher uptake of nitrogen, phosphorus and potassium by the crops.

In general, though the ridge planting under control plots had higher values of all the characters under study but both methods of seeding ridge as well as flat under control plots were superior to other treatments in all respect.

On the basis of experimental findings, the following conclusions were drawn :

(1) Growth and yields of black gram and green gram were adversely affected due to soil submergence and the seedling stage was relatively more susceptible than the flower initiation stage. Therefore, it would be advisable to manipulate agro-techniques to avoid soil submergence at seedling stage.

(2) The duration of soil submergence also affected the crops and, therefore, the extent of damage further can be minimised by providing suitable means of drainage to drain the excess rain water to minimise the duration of waterlogging to increase the grain yield.

(3) Ridge method of seeding was found to be the best method of seeding as it gave the highest yields of grain legumes. Therefore, under situation where soil submergence prevails during *kharif* seasons, farmers should grow black gram and green on ridges to get richer harvest.

(4) Black gram being less susceptible to soil submergence should be preferred as *kharif* grain legume over green gram under prevailing weather conditions of eastern Uttar Pradesh.

(5) It was clearly observed that the soil submergence reduced the nodule weight of crops which affected nitrogen supply to crop plants and ultimately these together resulted in lower crop productivity. It was further observed that the rate of recovery of affected plants was more when they were young and duration of waterlogging was prolonged. Therefore, this information would be useful in developing the fertilizer application practices to exploit grain production of *kharif* pulses.

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EFFECT OF NITROGEN, SULPHUR AND MAGNESIUM ON GROWTH, YIELD, OIL CONTENT AND QUALITY OF MUSTARD (*BRASSICA JUNCEA* L. CZERN & COSS) VAR. T-59 UNDER DRYLAND CONDITION

Ravikant R. Upasani Sup : *Dr. N. M. Misra*

The present investigation entitled "Effect of Nitrogen, Sulphur and Magnesium on Growth, Yield, Oil Content and Quality of Mustard (*Brassica juncea* L Czern and Coss) Var. T-59 Under Dryland Condition" was carried out at the research farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during Rabi seasons of 1979-80 and was repeated in Rabi season of 1980-81 with the objective to study the different rates of nitrogen, sulphur and magnesium on mustard crop and their economics on salable products. The topic of research was divided in two experiments as Experiment N. 1 and Experiment No. 2.

Experiment No. 1

This experiment was conducted in a split plot design to study the response of mustard to three levels (15, 30 and 45 kg/ha) of nitrogen as main treatment and four levels (0, 30, 60 and 90 kg/ha) of sulphur as subtreatment.

Experiment No. 2

In this experiment effect of magnesium on mustard was studied. The experiment was laid out in a randomised block design having four levels (0, 50, 100 and 150 kg/ha) of magnesium replicated six times.

Observations on Crop :

Various observations on crop like plant height, number of functional leaves, leaf area index, number of primary and secondary branches per plant, dry weight of leaves and stems, number of siliqua/plant, siliqua-size, number of grains/silique, seed and straw yield were recorded. Amongst mineral composition, nitrogen, phosphorus and sulphur or magnesium content (as the case may be) in the seed and stem part were recorded. Biochemical assays were performed for determining protein, methionine, cystine and oil content in seed and allyl isothiocyanate content in cake.

Weather Condition During Crop Period and Soil-Moisture :

Weather during first year of experiment i. e. 1979-80 was more favourable than 1980-81. During the first year, the distributipn of

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rainfall was good. Major part of rainfall (42.1 mm) was received during the week following sowing. During second year of early and later parts of crop growth, the weather remained dry and major rainfall was confined to between the last week of December and January.

The total soil moisture upto depth of 120 mm during the first and second year were 430.13 and 412.20 mm respectively.

Summary of the Results :

Effect of Nitrogen on Growth :

It was clear from the data on plant height that at the final stage of the crop rates of 30 and 45 kg N/ha produced significant increase in plant height over 15 kg N/ha during 1979-80 and 1980-81 respectively.

Nitrogen had favourable effect on number of functional leaves and leaf area index of the plant. It was observed that a rate of 30 kg N/ha during 1979-80 and 45 kg N/ha during 1980-81 produced significantly higher number of functional leaves and leaf area index.

Nitrogen had significant effect on the dry weight of leaves/plant at the later stages of crop growth. It was observed that a dose of 30 kg N/ha during 1979-80 and 45 kg N/ha during 1980-81 produced significantly more dry weight of leaves/plant over lower rates of nitrogen applied. A highly significant increase in dry weight of stem/plant was observed due to 30 and 45 kg N/ha during first and second year respectively.

Data on number of primary and secondary branches per plant showed that during 1979-80 there was a non-signifinant increase upto the highest dose of nitrogen applied i. e. 45 kg N/ha while during 1980-81 a rate of 45 kg N/ha was significantly superior to control.

Effect of Nitrogen on Yield Attributes and Yield :

Data on effect of nitrogen on yield attributes revealed that during 1979-80 and 1980-81, 30 and 45 kg N/ha respectively brought up significant effect on number of siliqua/plant and length of silique over lower rates of nitrogen applied.

Nitrogen had also significant effect on number of seeds per silique at 45 kg N/ha during both the years. So far as seed yield/ha was concerned it was noted that during 1979-80 a non-significant increase in seed yield was observed upto 30 kg N/ha whereas during 1980-81 the yield was found to be significantly more at 45 kg N/ha over 15 kg N/ha.

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The straw yield increased upto 45 kg N/ha during 1979-80 though the enhancement was not significant. However, during 1980-81 rates of 30 and 45 kg N/ha were found to be significantly superior over 15 kg N/ha.

Effect of Nitrogen on Qualitative Characters :

The nitrogen per cent in seed and stem was found to increase significantly at 30 and 45 N/ha over control during the both years of experimentation except in stem during 1979-80. A non-significant increase in phosphorus in seed and stem was observed during both the years. Nitrogen had no significant effect on sulphur content of mustard seed and stem during both the years.

The methionine content was found to be more at 45 kg N/ha while higher per cent of cystine was found at 30 kg N/ha. The protein per cent in seed and allyl-isothiocyanate content in cake was significantly more at 45 kg N/ha over control during both the years of experimentation.

Oil per cent in seed was found to be reduced significantly as the rate of nitrogen increased from 15 to 45 kg N/ha during both the years.

Effect of Nitrogen on Moisture Use Efficiency :

A non-significant effect on moisture use efficiency was observed during 1979-80 while during 1980-81, 45 kg N/ha enhanced the moisture use efficiency when compared with 15 kg N/ha.

Effect of Sulphur on Growth :

During the year 1979-80, at the final stage of crop growth a non-significant increase in plant height was observed upto 90 kg S/ha whereas during 1980-81, 60 and 90 kg S/ha increased the plants height significantly over control.

The dry weight of leaves/plant increased significantly due to sulphur during both the years. It was observed that at 90 days after sowing during 1979-80, 90 kg S/ha significantly increased the dry weight of leaves over control and during 1980-81 the dry weight of leaves/plant was more due to 30, 60 and 90 kg S/ha over control. A non-significant increase in dry weight of stem/plant due to sulphur application was observed during 1979-80 whereas during 1980-81, 60 and 90 kg S/ha produced significantly more dry weight of stem/plant over control treatment.

Data on number of functional leaves/plant and leaf area index revealed that all levels of sulphur significantly increased both these

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characters in comparison to control during both the years of experimentation.

Sulphur had significant effect on number of primary branches/plant during 1979-80. It was found that during that year 60 kg S/ha produced higher number of primary branches over control whereas during 1980-81 it did not increase significantly. As far as number of secondary branches per plant was concerned it was observed that during 1979-80 it increased upto 30 kg S/ha. During 1980-81, 60 and 90 kg S/ha produced highly significant increases in number of secondary branches over control treatment.

Effect of Sulphur on Yield Attributes and Yield :

Data on effect of sulphur on yield attributes and yield revealed that during 1979-80, the siliqua number per plant at 30, 60 and 90 kg S/ha were significantly superior over control. Increases in siliqua-size and number of seeds/silique were also significant at the higher doses of sulphur during both the years.

The seed yield of mustard was found to be significantly higher during both the years at 30, 60 and 90 kg S/ha over control. However, during 1980-81 there was significant reduction in yield from 60 to 90 kg S/ha. The straw yield showed non-significant increasing trend as the rates of sulphur increased upto the highest dose of sulphur i. e. 90 kg/ha during 1979-80. During 1980-81, application of 60 kg S/ha increased the straw yield significantly in comparison to control.

Effect of Sulphur on Qualitative Characters :

Data on effect of sulphur on nitrogen, phosphorus and sulphur percentage in seed and stem showed that all the treatments were significantly superior over the control.

The methionine and cystine content were found to be increased due to sulphur upto 6o kg/ha during 1979-80. The protein content in seed was also found to be significantly superior at 30, 60 and 90 kg S/ha over control. The allylisothiocyanate content in cake during 1979-80 at 30, 60 and 90 kg S/ha and during 1980-81 at 60 and 90 kg S/ha were found to be significantly superior over control.

Sulphur had marked effect on oil content of mustard seed. It was observed that during 1979-80 oil per cent at 30, 60 and 90 kg S/ha and during 1980-81 at 60 and 90 kg S/ha were found to be significantly superior over control.

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Economics of Nitrogen and Sulphur Fertilization :

So far as economics of nitrogen fertilization on mustard crop is concerned, it was noted that highest net income was found at 30 and 45 kg N/ha during 1979-80 and 1980-81 respectively, and additional income on per rupee investment on nutrient was highest at 30 kg N/ha during both the years. In case of sulphur fertilization it was observed that both, the highest net income and per rupee investment on nutrient, were highest at 30 and 60kg S/ha during 1979-80 and 1980.81 respectively.

Experiment No. 2 :

Effect of Magnesium on Growth :

Magnesium had significant effect on plant height during both the years of experiments It was found that during 1979-80 a rate of 50 kg Mg/ha had significant effect on plant height over control. During 1980-81, 150 kg Mg/ha produced significant reduction in plant height at the final stage of crop. The dry weight of leaves and stems/plant during 1979-80 did not vary significantly. During 1980-81 it was found that 50 kg Mg/ha produced higher dry weight of leaves/plant, however, the dry weight of stem plant was not affected significantly. During 1979-80, number of functional leaves and leaf area index increased signifincantly at 50 kg Mg/ha whereas during 1980-81 they increased upto 50 kg/ha but thereafter decreased significantly upto the highest rate of magnesium applied i. e. 150 kg Mg/ha.

A significant increase in number of primary branches per plant was observed during 1979-80 at 50 and 100 kg Mg/ha over control whereas during 1980-81, there was a non-significant increase upto 50 kg Mg/ha. So far as number of secondary branches/plant is concerned, it was found that during 1979-80 the same increased upto 50 Mg/ha though the increase was a non-significant one. During 1980-81, a rate of 100 kg Mg/ha proved highly significant over control treatment at the final stage of crop.

Effect of Magnesium on Yield Attributes and Yield :

A significant increase in numher of siliqua/plant was observed during both the years of experimentation. During 1979-80, 50 kg Mg/ha produced significantly higher number of siliqua/plant whereas during 1980-81, 100 kg Mg/ha was the best treatment. Number of seeds/slique increased upto 50 kg Mg/ha during both the years, though during 1980-81 the increase was a non-significant one. Size of siliqua also increased significantly upto 50 kg Mg/ha which however reduced thereafter.

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During 1979-80, the seed yield of mustard increased non-significantly upto 50 kg Mg/ha whereas during 1980-81 a significant increase in yield was observed at 50 kg Mg/ha. So far as straw yield is concerned it was observed that magnesium had non-significant effect on straw yield during 1979-80, while during 1980-81, 100 kg Mg/ha produced highly significant increase in straw yield over control treatment.

Effect of Magnesium on Qualitative Characters :

Magnesium brought up significant increase in protein content of seed during both the years of experimentation at the highest levels of magnesium applied i. e. 150 kg Mg/ha. Nitrogen content in stem and phosphorus content in seed and stem did not differ significantly due to magnesium treatments.

Magnesium content in grain and stem was found to be affected due to magnesium fertilization. During 1979-80 rates of 150 and 100 kg Mg/ha was found to increase magnesium content in seed and stem respectively. Whereas during 1980-81 highly significant effect of magnesium on magnesium per cent was observed due to 100 kg Mg/ha. However, in case of stem there was a non-significant effect. As far as oil per cent in seed is concerned, it was found that a non-significant increase in oil content due to magnesium existed during both the years of experiments.

Economics of Magnesium Fertilization on Mustard Yield :

Application of magnesium at 50 kg/ha or more than that rate did not prove economical to mustard crop. As the rate of magnesium increased the net income was reduced in comparison to control.

Conclusion

1. Nitrogen and sulphur had marked effect on growth, yield and qualitative character of mustard crop during both the years while magnesium had adverse effect on these aspects.
2. Rate of 30 and 45 kg nitrogen per hectare during 1979-80 and 1980-81 respectively, 60 kg sulphur and 50 kg magnesium per hectare during both the years was required to produce highest yield of mustard.
3. Fertilization with nitrogen and sulphur increased the moisture use efficiency during both the years.
4. The most profitable rates for nitrogen, sulphur and magnesium for 1979-80 and 1980-81 were 28.21, 39.75 kg nitrogen per

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hectare; 49.10, 46.71 kg sulphur per hectare and 18.75, 33.00 kg magnesium per hectare, respectively.

Future Line of Work :

The present investigation has proved the beneficial effect of nitrogen and sulphur in mustard cultivation. Due to seasonal variation (rainfall), results were quite different in two seasons and specific recommendations are difficult. Therefore, it is necessary to continue work to establish doses of nitrogen and sulphur that can be recommended for dryland farmers.

Work on time and form of sulphur application in which it should be applied may also be carried out to give a complete package with regard to sulphur management in mustard cultivation. In case of magnesium its lower rates and forms other than chloride form should be taken into consideration for future investigation.

EFFECT OF DIFFERENT MOISTURE REGIMES ON CHICKPEA—MUSTARD MIXTURES

Subhash Chander Gupta Sup : *Dr. R. A. Singh*

The importance of grain legumes, besides being used as food, lies in the maintenance of soil fertility and bringing about stability in crop yields due to their atmospheric nitrogen fixing ability. Oil-seeds have a prestigious place in Indian Agriculture. Mustard yields the most important edible oil which cannot perhaps be easily replaced by any other edible oil. It is, therefore, obvious that there is a great need for increasing the production of mustard and pulse seeds. An attempt had been made in this investigation to maximize their production per unit area, per unit of time by growing them in mixtures under different moisture regimes. The investigation entitled "Effect of different moisture regimes on chickpea (*Cicer arietinum* L.)—mustard (*Brassica juncea* L.) mixtures" was carried out at the Research Farm, Institute of Agricultural Sciences, B. H. U., Varanasi during the years 1979-80 and 1980-81. Two experiments were laid out in a split plot design keeping levels of irrigation in main plots and cropping patterns in sub-plots. In one experiment, mustard and in the second experiment, chickpea constituted the main crop. The treatments consisted of three levels of irrigation, viz., no irrigation, one irrigation at 45 days after sowing and two irrigations—one at 45 days after sowing and the second at 50%

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pod formation stage (80-85 days after sowing for mustard and 120 days after sowing for chickpea) and cropping patterns, viz., mustard or chickpea normal, mustard of chickpea paired mustard or chickpea + 50% chickpea or mustard and mustard or chickpea + 75% chickpea or mustard in case of mustard-chickpea mixture where mustard was the main crop and chickpea was the intercrop or in case of chickpea-mustard mixture where chickpea was the main crop and mustard was the intercrop.

The experimental soil had sandy clay loam texture of average fertility. A uniform basal dose of 18 kg N/ha and 46 kg P_2O_5/ha by the sides of chickpea rows and a dose of N, P, K @ 60 kg N/ha, 40 kg P_2O_5/ha and 30 kg K_2O/ha by the sides of mustard rows were applied. Half the amount of N through area was applied at the time of sowing and the remaining half 30 days after sowing. The salient features of the results obtained are given hereunder.

Mustard-Chickpea Intercropping

Increasing levels of irrigation significantly increased the number of branches and dry weight per plant. Among the cropping patterns mustard + 75% chickpea was significantly superior to rest of the treatments during both the years. Interaction effect of irrigation and cropping patterns was found to be significant in case of number of branches per plant only.

Increasing levels of irrigation increased the sunlight interception and mustard + 50% chickpea and mustard + 75% chickpea resulted in more sunlight interception over pure stands of mustard. Mustard + 50% chickpea and mustard + 75% chickpea proved superior to normal and paired planting of mustard in respect of number of pods and grains weight per plant. These yield attributes were not affected by the interaction of irrigation levels and cropping patterns. One irrigation at 45 days and two irrigations—one at 45 days and the second at pod formation stage (80-85 days after sowing) significantly increased the grain and straw yields of mustard to no irrigation but both were at par between themselves except the grain yield in the year 1980-81. The pooled yield data of two years revealed that one and two irrigations were comparable in respect of grain yield per hectare. Mustard + 50% chickpea and mustard + 50% chickpea were found to be significantly superior to normal and paired planting of mustard in affecting the grain and straw yields of the main crop. Interaction effect on both these characters were not significant.

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Two irrigations gave a marginal net increase of Rs. 238.9 and 382.4 over one irrigation level in the first and the second year, respectively. Intercropping of mustard with chickpea resulted in substantial increase in net return per hectare over pure planting of solid mustard. Mustard +75% chickpea was found to be the best.

Two irrigations caused the highest uptake of N P K in grains and straw over one irrigation and no irrigation during both the years. Intercropping systems proved to be superior to sole planting of mustard in this respect.

Oil content of mustard seeds and oil production per hectare increased due to the irrigation as compared to no irrigation but oil content of seeds decreased slightly due to two irrigations as compared to one irrigation.

The economics of irrigation treatments when compared on mustard equivalent basis revealed that one irrigation resulted in Rs. 300.2 more net return per hectare as compared to two irrigations in the first year but during the second year, two irrigations resulted in a slight increase in the net return per hectare (Rs. 138.3) as compared to one irrigation. Mustard+75% chickpea was found to be superior to all the other cropping patterns in respect of grain yield as well as net monetary return per hectare followed by mustard+50% chickpea.

Two irrigations resulted in higher total moisture use and lower moisture use efficiency as compared to one irrigation. Paired planting of mustard used the maximum (202 mm) amount of water but mustard +75% chickpea gave the highest WUE. It was found that drier the soil water status, more moisture was extracted from the lower horizons (60 – 120 cm depth) of the soil. On the other hand, more moisture was extracted from the upper horizons (0 – 60 cm) of the soil in the wet soil moisture regimes.

Land equivalent ratio was the highest in case of mustard+75% chickpea at all the irrigation levels.

Chickpea-Mustard Intercropping

One and two irrigations brought about significant increase in the number of branches per plant as compared to no irrigation. Significant variations in this respect between one end two irrigations was also recorded. Normal planting of chickpea was significantly superior to all the other patterns of planting as far as the number of branches per plant was concerned. Interaction effect of irrigations and cropping patterns on number of branches per plant was also significant.

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Increasing levels of irrigation increased dry matter production per plant. Normal and paired planting were superior to both the intercropping patterns with regard to dry matter production per plant and dry matter accumulation per plant per day. One irrigation recorded the highest sunlight Interception.

One and two irrigations were comparable between themselves so far as their effect on number of pods per plant was concerned. Normal planting of chickpea was found to be superior to other patterns of planting in this respect.

One and two irrigations produced significantly more test weight and higher grain weight per plant as compared to no irrigation. Sole planting of normal chickpea produced the highest 1,000 grain weight as well as grain weight per plant. Interaction effect of these factors was significant in case of grain weight per plant. One and two irrigations produced significantly higher grain and straw yields per hectare over control. Pooled data of two years showed that the effects of one and two irrigations in respect of grain yield per hectare were comparable. Normal and paired patterns of planting resulted in significant increase in grain yield as compared to chickpea+50% mustard and chickpea+75% mustard which also varied significantly between themselves. On the other hand, both the intercropping patterns resulted in significant increase in straw yield over normal and paired planting of chickpea in both the years.

The additional return obtained from the yields of the intercrop increased the total net return from the intercropping systems over that of sole planting of chickpea.

One irrigation resulted in higher monetary returns per hectare over no irrigation and slightly lesser return as compared to two irrigations. Chickpea+50% mustard yielded the highest net profit per hectare.

One and two irrigations resulted in higher N. P. K. uptake in grains and straw as compared to no irrigation. Among the cropping patterns, normal and paired planting of mustard resulted uptake values of these nutrients in intercropping treatments far exceeded those of sole planting of chickpea.

Land equivalent ratios were found to be higher in the intercropping patterns as compared to the sole planting of chickpea.

One irrigation resulted in the highest water use efficiency whereas the total moisture use was the highest under two irrigations. Chickpea+50% mustard used moisture with highest efficiency. Water

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extraction was found to be more from deeper soil layers (60-90 cm) under no irrigation while it was more from upper layers (0-60 cm) under one and two irrigations.

On the basis of the results obtained and their variations discussed, the following conclusions were drawn

1. One irrigation at 45 days after sowing was the best among various levels of irrigation tried for both the crops (mustard and chickpea). It resulted in higher water use efficiency and sunlight interception. The grain yield due to one irrigation was at par with two irrigations in the first year and marginally less in the second year. The results even on mustard equivalent basis go in favour of one irrigation level.

2. Paired planting of mustard as well as chickpea resulted in highest total moisture used.

3. Grain yield of mustard increased due to increase in plant population of chickpea as an intercrop (mustard+75% chickpea). On the other hand, increase in plant population of the intercrop-mustard in the main crop of chickpea reduced the grain yield of the main crop.

4. Among the cropping patterns, mustard+75%chickpea, in the mustard based experiment and chickpea+50% mustard in the chickpea based experiment were found to be the best in respect of grain yields and monetary net returns/ha. These intercropping patterns affected almost all the growth characters, yield attributes and yield and quality of seeds. They used soil moisture with the highest moisture use efficiency.

5. Mustard+75% chickpea and chickpea+50% mustard resulted in highest land equivalent ratios in their respective experiments.

6. Consumptive use of water (CU) was 206.1 mm and 254.3 mm under one irrigation in case of mustard and chickpea, respectively.

RESPONSE OF RICE VARIETY SAKET-4 TO VARYING MODES OF NUTRIENT SUPPLY TO SEED, SEEDLINGS AND TO THE FIELD

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Possibility of phenomenal increase in the productivity of cereals became apparent only after 1966 with the introduction of dwarf varie-

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ties, particularly in rice. Genetic engineering and artificial transmutation of genes have made rapid progress in developing such strains in rice, called as ideotypes which are expected to behave in a predictable manner within a defined environment. Essentially, for exploiting their genetic yield potentiality to the maximum, adequate supply of nutrients is a must. Since such ideotypes are known to possess the trait of high responsiveness towards heavy fertilizer incorporation, the increasing coverage of an area under their cultivation has greatly increased the fertilizer consumption in recent years. Domestic production of fertilizers in the country continues to lag behind our requirement. Imports in quantities sufficient to make up this shortfall, have also become uncertain. The situation has been further aggravated by the steep rise in prices of fertilizers. It has, therefore, become necessary to find out ways and means to economise the use of fertilizers by increasing the efficiency of applied nutrients in the cultivation of dwarf indica rice varieties.

The present project entitled "Response of Rice Variety Saket-4 to the Varying Modes of Nutrient Supply to the Seed, Seedlings and to the Field", is an effort towards this direction. Under the project two field experiments were planned and carried out at the research farm, Institute of Agricultural Sciences, Banaras Hindu University, for two consecutive years during kharif seasons of 1980 and 1981. In order to ascertain the mode and magnitude of response pertaining to the effect of various experimental variables, observations were recorded on morphological, yield and qualitative behaviour of the crop at different critical stages. Dwarf indica rice variety Saket-4 was selected as a test crop mainly because of wide adaptability in the locality coupled with its short growth duration and general suitability under irrigated condition of eastern part of U. P.

Experiment No. I

"Effect of Seed, Seed-Bed and Main Field Manuring on Growth, Yield and Quality of Saket-4"

This experiment was laid out in randomized block design with three replications. In all, 12 treatment combinations were tested. Details of the treatments are given below :

For seed treatment and seed-bed fertilization, four seed-beds of equal size (1 × 20 m) were prepared. In one of the seed-beds only water soaked seeds were sown without any fertilizer application. In other bed, water soaked seed were sown after the seed-bed was

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Table 1. Treatment/description of experiment No. 1

Treat-ments	Seed treatment	Seed-bed application	Main field treatments
T_1	None	None	None
T_2	None	DAP	None
T_3	None	DAP Recommended	N+K
T_4	None	None Recommended	N+K
T_5	None	DAP Recommended	N+P+K
T_6	None	None Recommended	N+P+K
T_7	1% KCl solution for 24 hours	None —	None
T_8	1% KCl solution for 24 hours	DAP —	None
T_9	1% KCl solution for 24 hours	DAP Recommended	N
T_{10}	1% KCl solution for 24 hours	None Recommended	N+P
T_{11}	1% KCl solution for 24 hours	DAP Recommended	N+P+K
T_{12}	1% KCl solution for 24 hours	None Recommended	N+P+K

DAP = Diammonium phosphate 2kg/40 m^2; N = Nitrogen 100 kg/ha
P = Phosphorus 60 kg/ha ; K = Potassium 50 kg/ha.

fertilized with diammonium phosphate (18% N+48% P_2O_5) at the rate of 2 kg/40 m^2. Seeds, duly treated with 1% KCl, were sown in third seed-bed without any fertilizer application. In the fourth seed-bed, application of diammonium phosphate at the rata of 2 kg/40 m^2 was made and seeds treated with KCl were sown. Sowing of the seed was done on the same day in each bed. Seedlings obtainad after 25th day of sowing were transplanted in well prepared main field as per the treatments.

In main field fertilization, total quantity of phosphorus and potash was applied at the time of land preparation. Application of nitrogen was split up into three, i. e., half of the total was applied as basal along with phosphorus and potassium, whereas the rest was applied

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in two equal splits coinciding maximum at tillering and panicle initiation stage.

On the basis of the results obtained in respect of morphological growth and yield attributes, grain and straw yield as well as qualitative aspect, following conclusions can be drawn :

(1) Main field fertilization with recommended rates of nitrogen, phosphorus and potash, i. e., 100 kg, 60 kg and 50 kg/ha, respectively in addition to 1% KCl seed treatment and DAP seed-bed fertilization brought about significant improvement in almost all the attributes and remained statistically superior to the rest of the treatment combinations.

(2) Main field fertilization with recommended quantities of nitrogen, phosphorus and potassium, without KCl seed treatment and/or DAP seed-bed fertilization proved almost at par in all respects.

(3) Main field manuring with nitrogen and potassium coupled with or without DAP seed-bed fertilization as also main field fertilization with nitrogen and phosphorus plus seed treatment with KCl were significantly superior to main field fertilization with nitrogen alone at the rate of 100 kg/ha with KCl seed treatment and DAP seed-bed fertilization,

(4) Application of nitrogen (100 kg/ha) in main field with KCl seed treatment and DAP seed-bed fertilization, however, established its significant superiority over no main field manuring.

(5) Combination of 1% KCl seed treatment and DAP seed-bed fertilization, brought about distinct improvement in almost all the attributes over either seed treatment or seed-bed fertilization alone.

(6) KCl seed treatment as well as DAP seed-bed fertilization proved better than control.

(7) Application of nitrogen and phosphorus as per recommended dose, with KCl seed treatment remained almost at par with incorporation of nitrogen and potassium with DAP seed-bed fertilization.

(8) All the nutrient treatments proved instrumental in increasing the morphological, yield and qualitative attributes over control.

Experiment No. 2

"Effect of Different Rates of Phosphorus and Potash in Relation to Seedlings' Root Dipping in Nutrient Solutions on Growth, Yield and Quality of Saket-4"

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This experiment was planned and carried out basically to study the effect of root dipping in relation to main field manuring. Two rates of phosphorus (30 and 60 kg P_2O_5/ha) and potassium (25 and 50 kg K_2O/ha) were tried as main factor in the experiment. Four different nutrient solutions with their recommended concentrations, namely, KCl (1%), DAP (3%), $MnSO_4$ (4%). $ZnSO_4$ (3%) and control (distilled water) were tested for seedlings' root dipping before transplanting. Experiment was laid out in split plot design assigning rates of phosphorus and potassium to main plots and root dipping in nutrient solutions to sub-plots. Treatments were replicated thrice. An uniform application of 100 kg N/ha was made in all the plots in three split applications at the rate of half at transplanting, one-fourth at maximum tillering and rest at panicle initiation stage. Phosphorus and potash were applied as basal at the time of land preparation through single superphosphate and muriate of potash, respectively.

For root dipping treatments, twentyfive days old seedlings were dipped in different nutrient solutions for about twentyfive minutes. Thereafter, seedlings were kept for about thirty minutes under shade before transplanting.

Response of treatments was studied on morphologjcal growth, yield and qualitative attributes of the test crop, variations in morphological growth behaviour were observed at different four growth stages with an interval of 20 days starting from 30th day after transplanting. Yield attributes and yield of grain and straw were studied at the time of harvest and samples were taken and subjected to chemical analysis for different components

Effect of Phosphorus and Potash

Almost all the morphological growth attributes showed significant improvement at all the growth stages due to the application of phosphorus and potash. Increasing rates of their application brought about marked increase in all the growth attributes. Phosphorus applied at the rate of 60 kg P_2O_5/ha established its marked superiority over 30 kg P_2O_5/ha. Similarly, incorporation of 50 kg K_2O/ha proved significantly superior to 25 kg K_2O/ha.

Like growth attributes, all the yield attributes as well as grain and straw yield profoundly increased due to phosphorus and potash application. Their higher rates of application showed marked superiority over lower rate. Interestingly enough, individually both phosphorus and potash produced significant improvement in all the yield attributes, but

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their interaction remained almost ineffective both in respect of growth and yield attributes.

Nitrogen content of plant recorded at various growth stages together with nitrogen, phosphorus and potash content in grain and straw exhibited significant increase due to phosphorus and potash application. Their higher rates of application proved superior to lower rates. Similar trend of response was noted in case of uptake and translocation of nitrogen, phosphorus and potassium in grain and straw as well as their total uptake. Interaction of phosphorus and potash, however, failed to produce any marked variation in these attributes.

Effect of Root Dipping

Seedlings' root dipping in nutrient solutions brought about significant improvement in all the growth attributes at all the stages over control, i. e., root dipping in distilled water. Root dipping in major nutrients, i. e., KCl and DAP showed their significant superiority over root dipping in micro-nutrients solutions ($MnSO_4$ and $ZnSO_4$). However, among the major nutrients, root dipping in 3% DAP established its marked superiority over KCl root dipping. Although almost all the growth attributes showed relatively higher value due to seedling root dipping in $MnSO_4$ solution than $ZnSO_4$, yet they remained statistically at par.

Similar to the growth attributes, all the yield attributes and yield of grain and straw responded exactly in the same pattern. Root dipping of the seedling in major nutrients significantly increased all the yield attributes of grain and straw yield over root dipping in micro-nutrients. Use of 3% DAP solution for seedling root dipping proved markedly superior to all the treatments. This was followed by root dipping in KCl solution which proved its superiority over both the micro-nutrients, i. e., $MnSO_4$ and $ZnSO_4$. Seedling root dipping either in $MnSO_4$ or $ZnSO_4$ remained almost at par in their effectivity but significantly improved all the yield attributes of grain and straw yield over control.

Nitrogen content recorded at various growth stages showed similar pattern of response at all the stages. In as much as nitrogen, phosphorus and potassium content in grain and straw also showed greater values due to root dipping in diammonium phosphate than potassium chloride and micro-nutrients. Root dipping in 1% potassium chloride solution brought about marked increase in all these attributes over root dipping in both the micro-nutrients. Notwithstan-

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ding, $MnSO_4$ and $ZnSO_4$ root dipping though remained at par, but proved significantly superior over control.

It is interesting to note that inspite of ineffectivity of main and sub-factor interaction, root dipping in diammonium phosphate and potassium chloride in general showed greater values in respect of all the growth and yield attributes as well as yield of grain and straw. However, it was found true only in comparison to lower rates of phosphorus and potassium application in relation to diammonium phosphate and potassium chloride root dipping, respectively. Their higher rates of application induced greater improvement than root dipping in major nutrient solutions.

Recommendations

(1) Main field manuring with 100 kg N, 60 kg P_2O_5 and 50 kg K_2O per hectare along with seed treatment with 1% potassium chloride solution and diammonium phosphate seed-bed fertilization at the rate of 2 kg per 40 sq. m. may be adopted for obtaining maximum yields

(2) However, for economised use of fertilizer application of 100 kg N and 60 kg P_2O_5/ha with 1% potassium chloride seed treatment, may be adopted. Similarly, with main field manuring with 100 kg N and 50 kg K_2O per hectare, diammonium phosphate fertilization of seed-bed may be taken up.

(3) Under lower rates of phosphorus and potassium (30 kg P_2O_5 and 25 kg K_2O/ha) root dipping of seedling with 3% diammonium phosphate and 1% potassium chloride solution proved much effective in economising the fertilizer use.

"RESPONSE OF CHICKPEA (*CICER ARIETINUM* LINN.) TO SOURCES, LEVELS AND METHODS OF NITROGEN AND PHOSPHORUS APPLICATION UNDER RAINFED CONDITION"

Virendra Pratap Singh Sup. : *Dr. R. A. Singh*

Pulses being the chief source of vegetarian protein have a unique place in the dominantly cereal based diet of human beings as well as animal nutrition in India. Among the pulses, chickpea is considered to be the most suitable and remunerative crop under rainfed conditions

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mainly because of its extensive and deep root system coupled with its high magnitude of drought tolerance. However, per hectare chickpea yield in India is probably the lowest in the world mainly because of traditional methods of its cultivation. Information about nutritional requirement of chickpea particularly under rainfed conditions is lamatably lacking.

Therefore, the present investigation entitled "RESPONSE OF CHICKPEA (*Cicer arietinum* Linn.) TO SOURCES, LEVELS AND METHODS OF NITROGEN AND PHOSPHORUS APPLICATION UNDER RAINFED CONDITION" was carried out at the research farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during the year 1977-78 and 1978-79 on the same site and with same treatments with the following objectives :

1. To study the relative efficiency of Diammonium phosphate and Urea+Triple superphosphate as nutrient carriers for chickpea.
2. To work out the differential response of different rates of nitrogen and phosphorus application on growth and yield of chickpea.
3. To work out the best method of nitrogen and phosphorus application in chickpea under rainfed condition.
4. To investigate the moisture use pattern, and moisture use efficiency under different rates of fertilization.
5. To work out the economically suitable source, level, and method of nitrogen and phosphorus application to chickpea under rainfed conditions of Varanasi.

The experiment was laid out in a Randomized Block Design with chickpea variety T-3 as test crop, having sixteen treatments related to sources, levels, and methods of nitrogen and phosphorus application. Each treatment was replicated thrice. The observations were recorded after 45 days of sowing with an interval of 30 days till maturity.

The salient features of the research findings and broad conclusions derived from them are given below.

All the treatments of N,P application brought about significant increase in growth characters such as height, branches, dry weights of shoot, roots and nodules. Among the treatments, the sources of N,P did not exert significant effect. The levels of N,P however, exerted significant effects on growth characters of rainfed chickpea. In case of

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methods of N,P application, 3/4 basal + 1/4 foliar spray was found to be as good as entire basal application at the time of sowing. Both of these methods of N,P application were superior to 1/2 basal + 1/2 foliar spray. Water spray treatment was found to be at par with control.

In the same manner, the yield attributing characters such as the number of pods/plant, number of grains/pod, number of grains/plant, grain weight/plant, test weight and grain and straw yields responded significantly to nitrogen and phosphorus levels. There was no significant effect of sources of N,P on these characters of rainfed chickpea. As far as methods of N,P application are concerned, entire basal application was found to be at par with 3/4 basal + 1/4 foliar spray, but both were significantly superior to 1/2 basal + 1/2 foliar spray.

Application of nitrogen alone was found significantly superior to control but there was no significant difference between the two levels of nitrogen.

Total moisture-use, in general, remained higher during the first year, but moisture-use efficiency was higher in the second year due to higher grain yield and lesser moisture-use. Moisture-use increased with the increasing levels of nitrogen and phosphorus and moisture-use efficiency was enhanced markedly with the different treatments over control during both the years.

Higher net returns were obtained in the treatments in which 18:46 kg N:P_2O_5/ha were applied either as $\frac{3}{4}$ basal + $\frac{1}{4}$ foliar spray or as entire basal through either of the source i. e., DAP or Urea + TSP

Conclusions

On the basis of experimental findings, the following conclusions were drawn :

1. Under rainfed conditions, nitrogen and phosphorus can be applied in chickpea either through diammonium phosphate or urea plus triple superphosphate as both these sources were found to be equally effective.
2. Application of N,P at the rate of 18:46 kg N:P_2O_5/ha was found to be the best for rainfed chickpea.
3. Entire basal application of N,P was found to be as good as $\frac{3}{4}$ basal + $\frac{1}{4}$ foliar spray application for rainfed chickpea. However, entire basal application of N,P in furrows 2-3 cm below the seeds of chickpea seems to be more convenient for commercial fertilization of rainfed chickpea, hence it should be preferred.

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4. Moisture-use and moisture-use efficiency of rainfed chickpea were found to be higher when 18:46 kg N:P_2O_5/ha were applied irrespective of their sources and methods of application.

5. For rainfed chickpea, 18:46 kg N:P_2O_5/ha applied as $\frac{3}{4}$ basal + $\frac{1}{4}$ foliar spray or as entire basal was found to be most profitable.

Recommendations

On the basis of experimental findings and the conclusions drawn, the following recommendations for the successful cultivation of chickpea under rainfed conditions of Varanasi are made.

1. In alluvial soils of Varanasi, rainfed chickpea should be fertilized with 18:46 kg N:P_2O_5/ha for efficient utilization of soil moisture and profitable returns.

2. In rainfed chickpea, nitrogen and phosphorus should be applied in the furrows 2-3 cm below the seeds in the moist soil at the time of sowing.

3. Nitrogen and phosphorus may be given through DAP or Urea + TSP depending upon the availability of fertilizer at the time of sowing.

EFFECT OF SOIL AND FOLIAR APPLICATION OF ZINC AND COPPER ON GROWTH, YIELD AND QUALITY OF WHEAT VARIETY MALAVIA-12 (HUW-12) UNDER *BARANI* (RAINFED) CONDITION

Somineni Venkateswarlu Sup. : *Dr. N. M. Misra*

Introduction of high yielding and short duration Mexican wheat varieties have shown severe deficiency of major nutrients in most of our soils. Because, application of major nutrients in large quantities have induced the deficiency of micronutrients in major wheat growing area.

Therefore, application of micronutrients is highly essential to maintain the fertility status of our soil for sustained crop production even under *Barani* conditions.

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The role of micronutrients, particularly zinc assumes all the more importance in increasing agricultural production per unit area and per unit time. Next to zinc, copper plays an important role in the production of grain crops. It is promptly realised that the deficiency of micronutrients especially in alluvial soils, which were latent few years ago due to low level of production, are becoming apparent and accentuating year after year. The information available on the response of high yielding wheats to zinc and copper is inadequate under *Barani* condition, which accounts nearly 50 per cent of the area.

To envisage it the field trial was conducted at the Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The soil of the experimental fields was sandy clay loam with a pH 7.7 containing 0.405% organic carbon, 186 kg available N ha^{-1}, 11.4 kg available P ha^{-1}, 178 kg available K ha^{-1}, 0. 69 ppm available Zn and 0.92 ppm available Cu. An amount of 57.8 mm and 63.5 mm of rainfall was received during the crop growth period of 1979-80 and 1980-81, respectively. The maximum and minimum temperatures ranged from 19.3 to 30.3°C and 7.0 to 18.4°C in first year and from 18.0 to 32.8°C and 8.0 to 16.5°C in second year respectively during crop growth periods.

Treatments

A field trial was laid out with the following treatments in a split plot design with three replications for two consecutive years at B. H. U. Research Farm.

Methods of *application*	*Zinc levels*	*Copper levels*
m_1 = Ful soil (Basal)	Zn_0 = No zinc sulphate	Cu_0 = No copper sulphate
m_2 = Full foliar	Zn_1 = Zinc sulphate @ 6 kg ha^{-1}	Cu_1 = Copper sulphate @ 5 kg ha^{-1}
m_3 = ½ basal (Soil) + ½ foliar	Zn_2 = Zinc sulphate @ 12 kg ha^{-1}	Cu_2 = Copper sulphate @ 10 kg ha^{-1}

Three methods of application were kept in main plots and nine treatment combinations of zinc and copper were kept in sub-plots.

An uniform dose of 30 kg N, 40 kg P_2O_5 and 30 kg K_2O was applied ha^{-1} as basal before sowing in all the experimental plots through urea, superphosphate (Single) and muriate of potash. Micronu-

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trient salts were mixed along with major nutrients and were applied in plough furrows before seeding. About 30 kg of nitrogen was applied through foliage at tillering and jointing stages. Full foliar and half foliar applications of zinc and copper were done in equal splits along with urea spray at tillering and jointing stages.

The following conclusions were recorded during 1979-80 and 1980-81 :

Effect of Application of Zinc and Copper on Growth

Application of zinc and copper significantly enhanced all the growth attributes, viz., plant height, tillers per meter row length, number of green leaves and leaf area per plant. There was a marked improvement in growth characters by application of zinc and copper at higher doses (12 kg $ZnSO_4$ ha^{-1}; 10 kg $CuSO_4$ ha^{-1}) than their lower rates (6 kg $ZnSO_4$ ha^{-1}; 5 kg $CuSO_4$ ha^{-1}) of application. However, application of zinc was more pronounced than application of copper in increasing all the growth attributes.

Plant growth was superior when zinc and copper were applied as $\frac{1}{2}$ basal (soil) $+\frac{1}{2}$ foliar than their full foliar or full basal application.

The interaction effects were found to be non-significant in all growth characters.

Effect of Zinc and Copper on Physiological and Morphological Characters

Higher relative water content and total chlorophyll content was obtained by application of zinc and copper @ 12 kg $ZnSO_4$ and 10 kg $CuSO_4$ ha^{-1} than 6 kg $ZnSO_4$ ha^{-1} and 5 kg $CuSO_4$ ha^{-1}. Transpiration ratio decreased at tillering and jointing stages by application of zinc and copper as compared to control. Ear emergence was significantly earlier by application of zinc and copper than control. Ear emergence was earlier under 12 kg $ZnSO_4$ and 10 kg $CuSO_4$ ha^{-1} than under application of 6 kg $ZnSO_4$ and 5 kg $CuSO_4$ ha^{-1}. However, zinc was more beneficial than copper in increasing chlorophyll content, RWC and decreasing transpiration ratio and the number of days to ear emergence (75 %).

Application of zinc and copper through $\frac{1}{2}$ soil $+\frac{1}{2}$ foliar spray enhanced the chlorophyll content at flowering and dough stage than their full soil application.

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Application of Zinc and Copper on Yield Attributing Characters and Yield

Application of zinc and copper significantly enhanced all yield attributing characters, viz., tillers per meter row length, ear length, fertile spikelets per ear, ear weight and grain weight per plant/spike, number of grains per ear and test weight of grain. Significant enhancement in tillers per meter row length and test weight of grain was obtained only at higher dose of zinc and copper applied @ 12 kg $ZnSO_4$ and 10 kg $CuSO_4$ ha^{-1} than their lower dose applied @ 6 kg $ZnSO_4$ and 5 kg $CuSO_4$ ha^{-1}.

The pooled analysis of data of two years clearly showed that a marked increase in grain yield was observed by application of Zn (12 kg $ZnSO_4$ ha^{-1}) than application of Cu (10 kg $CuSO_4$ ha^{-1}). The mean increase in grain yield was 3.07 q ha^{-1} (15.03%) by application of Zn @ 12 kg $ZnSO_4$ ha^{-1} over control whereas, the increase due to copper application @ 10 kg $CuSO_4$ ha^{-1} was 1.47 q ha^{-1}, i. e., 6.90%.

Application of zinc and copper through $\frac{1}{2}$ soil+$\frac{1}{2}$ foliar method of application enhanced the grain yield by 0.70 and 0.76 q ha^{-1} over their full soil application during first and second year, respectively.

Effect of Zinc and Copper on Uptake of Major and Micronutrients

Application of zinc and copper significantly enhanced N and K uptake in grain and straw and their total uptake. Application of zinc also significantly increased P uptake whereas Cu had no significant effect on total uptake of P.

Application of zinc and copper significantly enhanced their uptake in grain and straw and their total uptake. Uptake was significantly higher by application of zinc and copper at higher doses, i. e., 12 kg $ZnSO_4$ and 10 kg $CuSO_4$ ha^{-1} than their lower doses, i. e., 6 kg $ZnSO_4$ ha^{-1} and 5 kg $CuSO_4$ ha^{-1}. The interaction effect of Zn × Cu was found significant on the uptake of total Zn in both the years. The treatments Zn_2Cu_1 and Zn_2Cu_2 significantly increased Zn uptake over Zn_1Cu_1 and Zn_1Cu_2, respectively.

Effect of Zinc and Copper on Moisture-use and Moisture-use Efficiency

Moisture-use and moisture-use efficiency (MUE) increased by application of zinc and copper but the increase was greater by zinc

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than copper. There is no marked difference in MUE by application of zinc and copper through different methods.

Effect of Zinc and Copper on their Residual Availability in Soil

Post harvest analysis of the soil showed a significant increase in the residual availability of Zn and Cu by application of zinc and copper in both the years. However, residual availability of Zn and Cu was significantly higher by soil application of zinc and copper over full foliar method of application. The interaction effects of zinc × methods and copper × methods were significant in both the years. Significantly higher available Zn and Cu were recorded under 12kg $ZnSO_4$ and 10 kg $CuSO_4$ ha^{-1} in both the years after harvest of wheat. Residual availability of Zn and Cu was higher after harvest of the crop during second year due to their successive applications.

Economics of Application of Zinc and Copper

Application of zinc alone was highly beneficial in increasing net profit.

Higher net profit (Rs. 677.2) was obtained by application of zinc @ 12 kg $ZnSO_4$ ha^{-1} under $\frac{1}{2}$ soil + $\frac{1}{2}$ foliar method as compared to net profit of Rs. 267.2 obtained by application of copper @ 10 kg $CuSO_4$ ha^{-1} under $\frac{1}{2}$ soil + $\frac{1}{2}$ foliar method.

RESPONSE OF MUSTARD TO APPLICATION OF FERTILIZERS UNDER IRRIGATED AND UNIRRIGATED CONDITIONS

Rajgrih Pandey Sup. : *Dr. Mahatim Singh*

The oilseed crops play a vital role in Indian Agriculture, industry and trade. These crops, not only serve a good source of energy and improve the dietary of the people but also provide vast opportunity for employment and enable the country to earn foreign exchange.

Rapeseed and mustard are important oilseed crops which occupy second position on the basis of acreage and production under oilseed group in the country. These are grown as pure as well as mixed crops under irrigated and rainfed conditions. The yield of these crops are very low as compared with many oilseed growing countries of the world. This is mainly due to an inadequate and imbalanced fertilization of the crop.

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Nitrogen, phosphorus and potassium are important elements in plant nutrition in Indian conditions. Among the nitrogenous fertilizers, sulphur containing fertilizers are reported to have beneficient effect in increasing production of oilseed crops. However, the informations available on these aspects on mustard crops in India are still meagre.

Two *experiments*, one under irrigated and the other under unirrigated conditions were conducted in Randomized Block Design with three replications at the Research Farm of the Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during 1975-76 and 1976-77 with the following objectives :

(a) To study the effect of levels of nitrogen and phosphorus along with the sources of the nitrogenous fertilizers on the growth and yield behaviour of mustard, variety 'Varuna' (T. 59).

(b) To find out the optimum levels of nitrogen and phosphorus, and

(c) To work out the economics of fertilization of mustard crop under irrigated and unirrigated conditions.

The factors under observations in the present experiment were three rates of nitrogen (30, 60 and 90 kg/ha), two rates of phosphorus (30 and 60 kg P_2O_5/ha) and two sources of nitrogen (ammonium sulphate and urea) along with an absolute control treatment under irrigated condition. For unirrigated crop, the treatment consisted of the combinations of three levels of nitrogen (20, 40 and 60 kg/ha), two levels of phosphorus (20 and 40 kg P_2O_5/ha), two sources of nitrogen (ammonium sulphate and urea) along with an absolute control.

40 kg and 30 kg K_2O per hectare were uniformally applied to all the plots in irrigated and unirrigated trials, respectively. Single superphosphate and muriate of potash were taken as sources of phosphorus and potassium. The higher doses of nitrogen and phosphorus were mainly considered for irrigated condition for obtaining the standard yield response.

The response of mustard to various treatments were measured in terms of quantitative and qualitative expressions. The quantitative characters included observations on : height of the plant (cm), dry matter per plant (g) at different stages, number of primary branches, number of secondary branches, number of siliqua per plant, length of siliqua (cm), number of seeds per siliqua, test weight of 1000 seeds (g), grain yield (q/ha), and straw yield (q/ha),

Qualitative and miscellaneous characters studied were oil content (%) in grain, oil recovery (q/ha), protein content (%) in grain, protein

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recovery (q/ha), uptake of nitrogen, phosphorus and potassium in grain and straw (kg/ha), response curve and economics of fertllizers.

The generalized and broad conclusions derived from investigations are given in the following paragraphs :

Nitrogen application at the rate of 90 kg/ha under irrigated conditions and 60 kg/ha under unirrigated conditions increased the height, dry matter, primary and secondary branches, number of siliqua/plant, length of siliqua, number of grains/siliqua, test weight of 1000 seeds (g), grain and straw yield (q/ha) and the harvest index.

Application of higher rates of nitrogen decreased the oil content of grain but increased the oil recovery (q/ha) protein content (%), protein recovery (q/ha), uptake of nitrogen, phosphorus and potassium in grain and straw under both the conditions.

Similarly, higher rates of phosphorus fertilization also showed a positive response on almost all the quantitative and qualitative characters studied under both irrigated and unirrigated conditions.

Between the sources of nitrogen, ammonium sulphate had better performance than urea with regards to quantitative and qualitative characters; whereas, the latter was found superior to former in respect of economic returns under both the conditions.

The experimental evidences thus, warrant the following specific recommendations which may, in general, be adopted for profitable cultivation of mustard under the existing conditions of soils and climate.

(1) Fertilization of mustard with nitrogen and phosphorus are conductive to better growth, development and yield under irrigated and unirrigated conditions.

(2) Agronomic efficiency of ammonium sulphate is better than urea, yet latter may be used as the most profitable source of nitrogen, based on the economic efficiency under both the conditions.

(3) The most profitable rates of nitrogen application were 114.60 kg N/ha for ammonium sulphate and 117.60 kg N/ha for urea under irrigated condition whereas, for unirrigated crop, the most profitable rates of nitrogen application were 42.60 kg/ha for ammonium sulphate and 49.00 kg/ha for urea.

(4) Application of phosphorus was also found to be more beneficial in increasing the yield of mustard than its absence. The most profitable rates of phosphorus were 45 kg P_2O_5/ha and 31.60 kg P_2O_5/ha for irrigated and unirrigated crops, respectively.

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ENTOMOLOGY & AGRICULTURAL ZOOLOGY

A STUDY ON THE ECONOMIC MANAGEMENT OF LIPAPHIS ERYSIMI (KALTENBACH) ON MUSTARD

Waryam Singh Sup. : *Dr. D. S. Mishra*

In the present investigation two sets of field experiments, each comprising of two field trials, were conducted on the research farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India, during *Rabi* seasons (November to March) of the year 1979-80, 1980-81, and 1981-82. Under first set of experiments the attempt was made to evaluate the efficacy of foliar sprays and granular soil applications of some promising systemic insecticides separately against *Lipaphis erysimi* (Kalt.) and to calculate cost/benefit ratio during the year 1979-80 and 1980-81. Second set of experiments was conducted to determine most profitable number of sprays, to quantify economic injury levels and to ascertain pest status in the year 1980-81 and 1981-82. All the experiments were conducted in randomised block design with Varuna T-59, a vaiety of *Brassica juncea* (L) group. Fertilizers were applied @ 50 Kg. nitrogen, 40 Kg. phosphorus and 40 Kg. potash per hectare. The insecticides evaluated were pirimicarb 50 WP, oxydemeton methyl 25EC, dimethoate 30EC, methamidophos 400 SC, vamidothion 30EC and phosphamidon 85SC as foliar sprays, and aldicarb 10G, carbofuran 3G. phorate 10G, mephosfolan 5G, disulfoton (disyston) 5G and disulfoton (solvirex) 5G as soil applications. The latter two granules were included only in second year trial.

Insecticidal sprays at 0.025 and 0.050% a. i. were applied 60 days after sowing both year @ 625 1/ha. The aphid counts were made 24 hours before and 24 hours, 4 days and 7 days after spraying. Granular soil application @ 1.00 and 2.00 kg. a. i./ha were made 35 days after sowing both the years and lower dose (1.00 Kg. a. i.) of each insecticide was repeated 77 days after sowing (42nd days after first application) in the second year. Weekly insect counts were taken till 56th day following insecticidal application on 35 days after sowing. In the trials on economic damage levels, the insecticide (phosphamidon 0.025%) was applied @ 625 1/ha when the infestation reached in the range of provisionally fixed treatment level. The infestation counts on

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the basis of pest population and % plant infestation were taken on every 3rd and 5th day respectively till the observations continued. The insect count data and the corresponding yield (q/ha) of trials on efficacy of insecticides were subjected to analysis of variance. The data on the infestation levels, number of sprays and the corresponding yield (q/ha) were subjected to regression analysis to establish yield infestation and protection rate and yield response relationships. The most profitable number of sprays and economic injury levels were determined as detailed in the chapter 'Materials and Methods'. The results obtained in the present study are summarised below. The efficacy of all foliar and granular treatments are described in detail in preceeding chapter IV.

All the insecticidal treatments gave significant aphid control over untreated throughout the period. Pirimicarb 0.050% was the highly effective chemical, though it did not differ significantly with vamidothion 0.050% on 24 hours and 7 days in the second year. Further, the efficacy of pirimicarb 0.025%, phosphamidon 0.050%, oxydematon methyl 0.050% and dimethoate 0.050% (except on 4th day in first year) was at par with vamidothion 0.050%. The lower does (0.025%) each of oxydemeton methyl, vamidothion and phosphamidon and higher dose (0.050%) of methamidophos were at par with each other though the order of efficacy differed. Dimethoate and methamidophos each 0.025% were the least effective treatments.

All the insecticidal treatments produced significantly higher yields 7.59 to 10.56 q/ha and 6.84 to 10.34 q/ha as compared to the untreated control 5.74 and 4.81 q/ha during both years, respectively.

Additional return over cost of treatment except pirimicarb and methamidophos ranged from Rs. 976.56 to Rs. 1860.98/ha. Vamidothion 0.050% gave maximum benefit followed by phosphamidon 0.050%. The benefit/cost ratio of treatments ranged from 12.56 : 1 to 24.64 : 1. The highest benefit/cost ratio was offered by phosphamidon 0.025% followed by vamidothion 0.025%.

Aldicarb 2.0 kg. a.i./ha was the highly effective treatment throughout though did not differ significantly with aldicarb 1.0 kg. a.i./ha upto 21 days after treatment. Further, mephosfolan 2.0 kg. a.i. and phorate 2.0 kg. a.i. were equally effective treatment till 28 days. On 35th day, phorate 2.0 kg. a.i./ha was significantly superior to mephosfolan 2.0 kg. a.i./ha which was at par with phorate 1.0 kg. a.i./ha. On 56th day, later treatment was also observed superior to mephosfolan 2.0 kg. a.i./ha.

In second year, the efficacy of aldicarb 2.0 kg. a. i./ha was similar to the findings of previous year till 42 days and was observed at par

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with aldicarb 1.0 kg. a. i./ha till 14 days. Further, mephosfolan, disyston, solvirex and phorate each at 2.0 kg. a. i./ha were equally effective till 28 days, though phorate 2.0 kg. a. i. was inferior on 7th day after application. On 35th day, disyston phorate and solvirex each at 2.0 kg. a. i./ha gave equal control. On 42nd day, following aldicarb 1.0 kg. a. i./ha and phorate 2.0 kg. a. i. was the next highly effective treatment except disyston 2.0 kg. a. i. On 49th day and 56th day, aldicarb 1.0+1.0 kg, a. i./ha was the significantly highly effective treatment followed by aldicarb 2.0 kg. a. i./ha and aldicarb 1.0 kg. a. i./ha each significantly different from the other, and superior to rest of the treatments. Both the doses of carbofuran were observed to be ineffective throughout the experimental period during both the years.

All the treatments except carbofuran produced significantly higher yield 11.29 to 18.09 q/ha and 10.21 to 17.22 q/ha as compared to untreated control 6.27 and 5.44 q/ha during both the years, respectively.

Additional return was less than the cost of treatments in carbofuran. Other treatments resulted in additional return over cost of treatment from Rs. 489.70 to Rs. 4148.15/ha. The maximum benefit was obtained from aldicarb 2.0 kg a. i./ha followed by aldicarb 1.0 kg. a. i./ha. However, phorate 1.0 kg. a. i./ha offered highest benefit/cost ratio followed by aldicarb 1.0 kg. a. i./ha.

Yield infestation relationship

The quantitative relationship between infestation and yield is essential for determining economic injury levels of infestation. This relationship enables to find out yield loss corresponding to any injury level. Among the various equations viz. linear, $\log_e$ linear, semi-$\log_e$ X and semi-$\log_e$ Y tried, the later found best fitting has been used to establish this relationship. The reduction in yield for every unit increase in infestation on the basis of aphid population was 0.00498 and 0.00368 q/ha and the corresponding values on the basis of per cent plant infestation were 0.01690 and 0.01645 q/ha for first and second year respectively.

Most profitable rate of sprays

In order to determine economic injury levels for foliar sprays, gain threshold has been calculated on the cost of control at most profitable rate of sprays. The most profitable rate of sprays was ascertained on the basis of quantitative relationship between yield and number of sprays.

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The maximum obtainable yield on the basis of % plant infestation was 12.85 and 13.55 q/ha at 5 sprays for both the years respectively, and corresponding values on the basis of aphid population were 11.36 and 13.77 q/ha at 4 sprays. The average most profitable rate of sprays was 4.77 sprays for % plant infestation and 3.79 sprays on the basis of aphid population.

The higher value of the most profitable rate of sprays on the basis of % plant infestation as compared with aphid population indicates that there is no strong correlation between increase in plant infestation and aphid population.

Economic injury levels

Economic injury levels of all the insecticide found promising as foliar sprays and/or as soil applications have been determined with the cost of control of both lower and higher dosage keeping in view the benefit and benefit/cost ratio. The economic injury levels for different insecticides on the basis of aphid population ranged from 9.42 to 13.32 aphids/plant and 15.21 to 23.49 aphids/plant for foliar sprays at 0.025% and 0.050% and from 9.42 to 15.21 aphids/plant and 19.08 to 30.60 aphids/plant for soil applications at 1.0 and 2.0 Kg. a.i./ha, respectively. Whereas, corresponding EIL values, on the basis of % plant infestation, ranged from 2.65 to 3.80 % and 4.36 to 6.76% for foliar sprays and 2.14 to 3.45% and 4.10 to 6.94% for soil applications.

The increase in economic injury levels with increase in cost of control depicted a positive response of economic injury levels to cost of control.

Pest status

The average aphid infestation on both the basis i. e. population as per cent plant infestation was not a single year below or even near to the highest injury level established under present study.

According to the categorization made by Stern *et al.* (1959) the *Lipaphis erysimi* (Kalt.) is put in the category of severe pests and it required repeated application of insecticides to prevent economic damage.

Recommendations

The following treatments are recommended from view point of the economic status of the farmers growing Varuna T-59. The first recommendation gives higher benefits and suits to farmers who can invest

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more. The second offers higher benefit/cost ratio and can best be adopted by farmers with less capital.

1. Spray vamidothion 30EC or phosphamidon 35SC at 0.050% a. i./ha @625 1/ha no sooner infestation reaches to 18.65 or 15.21 aphids/plant (15 cm central top soot); or 5.38 or 4.36 per cent plant infestation respectively.

Or

Soil application (in furrows) with aldicarb 10G @ 2.0 kg. a. i. or 1.0 kg. a. i./ha just when aphid population reaches 30.66 or 15.21 aphid/plant; or 6.94 or 3.45% plants are infested, respectively.

2. Spray phosphamidon 25SC or vamidothion 30EC at 0.025% a. i. @ 625 1/ha just when the aphid population is noticed at 9.42 or 11.08 aphids/plant or 2.65 or 3.16% plants are infested respectively.

Or

Soil application (in furrows) with phorate 10G or aldicarb 10G @ 1.0 kg. a. i./ha just when the infestations reaches at 9.42 or 15.21 aphids/plant or 2.14 to 3.45% plant infestation, respectively.

These recommendations are applicable upto complete pod formation stage of the crop. The impact of crop stages on EIL and insecticidal residues on seed has not been taken into consideration under present study.

TOXICITY AND ANTICHOLINESTERASE STUDIES OF MONOCROTOPHOS AND MALATHION ON *CLARIAS BATRACHUS* (L.)

Surendra Nath Mishra Sup. : *Dr. H. N. Singh*

The present study is aimed to find out the toxicity and anticholinosterase effects of monocrotophos and malathion on *Clarias batrachus* (L.), a fish commonly known as 'Mangur'. Fishes of 15-20 cm in size were obtained from local fish market and acclimated for 15 days in the laboratory conditions before they were used for various experiments.

Fish mortality was recorded at a series of insecticidal concentrations in tap-water for different exposures till complete mortality occured. The experiment was conducted in 3 replications in round aluminium

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containers of 12 L capacity. 10 fishes were used for one replication. The data was subjected to Finney's (1952) treatment for probit analysis.

The cholinesterase activity was determined by Hestrin (1949) method in brain, muscle, liver, alimentary canal, kidney, heart, spleen, and ovary using acetylcholine (ACH), acetyl methylcholine (A β Mech) and butyrylcholine (BuCh) as substrates. Median inhibition concentration and the inhibition constants were studied *in vitro*, the reaction followed the first order kinetics. Both the toxicity and the enzyme studies were carried out at ambient temperature (28±1.0°C). The salient findings are summarised as below :

(1) Monocrotophos proved more toxic to *Clarias batrachus* than malathion. The sublethal and lethal concentration for monocrotophos at 60 hr exposure were recorded to be 5 and 20 ppm, respectively. The respective values for malathion were 15 and 33 ppm. As low as 8 ppm of monocrotophos caused complete mortality in 108 hr of exposure. Malathion, even at 18 ppm did not cause any mortality up to 40 hr, but with the increase in exposure duration the mortality reached to 100% within 88 hr. This time lag for malathion is perhaps necessary for its conversion into malaoxon.

(2) LC_{10}, LC_{50} and LC_{90} values for monocrotophos were determined to be 5.99, 12.45 and 25.82 ppm, respectively, for 60 hr exposure. The respective values for malathion were 17.29, 24.48 and 34.51 ppm. The LT_{50} values for monocrotophos and malathion at 60 hr LC_{50} were 61.00 and 66.43 hr, respectively. These values at $2 \times LC_{50}$ (25.00 ppm for monocrotophos and 50 ppm for malathion) were 20.00 and 22.39 hr.

(3) Acetylcholinesterase (AChE) activity, in terms of mM of ACh hydrolysed/g body tissue/hr was highest in brain (117.99) followed by muscle (101.41), liver (79.10), kidney (66·54), alimentary canal (25.29), heart (8.58), spleen (3.92), and ovary (2.62). A β MeCh was hydrolysed at a slower rate than AChE, but the AChE followed the same order, except liver which recorded slower enzyme activity than the kidney. Only brain failed to hydrolyse A β MeCh. No hydrolysis was recorded with BuCh suggesting the absence of pseudo-ChE in these organs.

(4) The concentration vs activity plots, both with ACh and A β MeCh, yielded a bell shaped curve showing the phenomenon

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of substrate inhibition at higher concentrations. The pS optima were same for the two substrate, but varied significantly with the tissues being 10^{-2}M with AChE from brain, muscle, liver, kidney, and alimentary canal; 4.5×10^{-3}M for heart; and 10^{-3}M for spleen and ovary.

(5) Affinity of the substrate to AChE, as indicated by Michaelis-Menten constant (Ka), varied with the organ. ACh showed higher affinity than A β Mech with the AChE from muscle, kidney, and alimentary canal: no such difference was observed with liver. Km values as determined by the Line Weaver and Burk (1932) plotting for AChE from brain, muscle, kidney, liver, and alimentary canal hydrolysing ACh were 10.0×10^{-3}, 12.5×10^{-3}, 6.6×10^{-3}, 4.4×10^{-3}, and 7.1×10^{-5}M, respectively. These values for A β MeCh hydrolysis were 20×10^{-3}, 4.0×10^{-3}, and 10.00×10^{-3}M in case of muscle, kidney, liver, and alimentary canal, respectively.

(6) Insecticide concentration inhibiting 50 per cent of AChE activity (I_{50}) range from 9.226×10^{-7} to 7.112×10^{-3} for monocrotophos and 2.113×10^{-6} to 5.433×10^{-3} for malathion in the different body tissues of the fish. I_{50} values were lower in case of monocrotophos as compared to malathion for AChE from brain, kidney, and alimentary canal, when 0.01 M ACh was used to block the inhibition reaction. This suggests monocrotophos to be 1.5 to 7.0 times potent inhibitor than malathion. For liver and muscle, malathion was more potent inhibitor. Brain was found to be the most sensitive for inhibition with monocrotophos as well as malathion followed by kidney, alimentary canal, liver, and muscle. The decreasing order of AChE sensitivity to inhibition with both the insecticides, when A MeCh was used to block the inhibition reaction, was—liver=kidney>alimentary canal>muscle. I_{50} values for both the insecticides were significantly higher in case when ACh was use to block the inhibition reaction than those when A MeCH was used for this purpose.

(7) The bimolecular rate constant (Ki), determined by the Wilkinson's (1961) treatment, was found to be higher, in general, in case of monocrotophos than malathion with all the body tissues. Monocrotophos recorded Ki in the order : brain> kindney>alimentary canal >muscle. This order in case of

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malathion was—brain>alimentary canal>liver>kidney>muscle. Higher Ki of malathion with alimentary canal AChE was due to the very high affinity and phosphorylation between; the Ka being higher than that of the brain. In general Ki in a particular organ was associated with lower value affinity constant (Ka) and higher phosphorylation constant (Kp).

(8) Ka and Kp for both insecticides varied with the organ as well as substrate. With monocrotophos, when ACh was used to block the inhibition reaction, Ka was found lowest in brain (1.010×10^{-7} M) followed by kidney, alimentary canal; it was highest in muscle (3.184×10^{-7} M). Values of Kp were in the inverse order of Ka for the various tissues. When A β MeCH was used to block the inhibition reaction, the values of Ka were generally lower as compared to those when ACh was used as substrate; but the pattern from different organs was similar. The values of Kp were lowest (0.014 min^{-1}) for kidney. The lowest Ka showing the highest affinity between AChE and malathion with ACh substrate was observed in alimentary canal. Muscle showed the least affinity with malathion when A MeCh was used as substrate. Ka was lowest in alimentary canal (0.991×10^{-7} M) and highest in the muscle (2.17×10^{-7} M). Kp in this case was highest for liver (0.246 min^{-1}) and lowest for muscle (0.054 min^{-1}). Phosphorylation and affinity constants suggest higher potency of monocrotophos to be due to its higher phosphorylation rate with the enzyme.

A rough estimate of these insecticides in paddy field water following a single spray on the crop was worked out. For malathion a. i. (active ingradient), the recommended dose is 1250 ml/ha. If one fourth of the chemical comes to paddy field standing water of 15 cm depth, the contamination level reaches up to 0.208 ppm. Similarly, monocrotophos @ 500 ml a. i./ha gives 0.083 ppm concentration. Taking one third of the insecticide drain off, the respective concentrations for the two insecticides in water give rise 0.278 and 0.111 ppm.

The results are documented by 15 illustrations and 20 Tables. The present findings are comprehensively compared with those of similar nature reported in literature The causes of difference, if any, from earlier works and their implications are thoroughly discussed.

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EFFICACY OF SOME INSECTICIDES AGAINST INSECT PESTS OF *CAPSICUM ANNUM* L. AND THEIR RESIDUES IN THE CROP

Sanjay M. Mulmule, Sup. : *Dr. H. N. Singh*

Chilli is one of the important crops grown for the value of its fruits, making spices and condiments. It covers an area, among vegetables, next to potato to occupy 626.3 thousand hectares with annual production of 510.9 thousand tonnes of dry chilli. It fetches the valuable foreign exchange of Rs. 83.18 lakhs.

The area under this cash crop is reducing since last decade because of the dreadful disease leaf curl. This leaf malformation is caused either by direct injury or due to transmission of virus by the tiny arthopods, viz., thrips *(Scirtothrips dorsalis* Hood), aphids *(Aphis gossypii* Glover), mites (*Phytophagotarsonemus latus* Banks) and white flies *(Bemisia tabaci L.)*. Besides, this crop is also reported to be attacked by more than a dozen pests belonging to order Lepidoptera, Diptera and Hemiptera. Twentyfive to ninety per cent loss in yield has been reported to be caused by either the sucking pests or by leaf curl in this crop.

The literature shows the chemical control of these insects as the only resort to check the pest population as well as the disease. The insecticides have to be applied right from transplantation to maturity of the crop since small number of insects at any stage of the crop can cause the disease. A number of organophosphorus and carbamate insecticides have been reported to reduce the pest population and the disease incidence in chilli else where, but no crop protection schedule has been evaluated for pest complex of chilli in this agro-climatic region.

Use of these chemicals raises the problem of their residues in the crop and thus of waiting periods, particularly, for a vegetable crop like chilli the fruits from which are invariably plucked weekly. Surprisingly enough, such information on residues of more promising insecticides like carbaryl and monocrotophos are lacking on chilli except the three studies on residues of monocrotophos following single spray application.

With this, the present investigation was aimed (a) to study the comparative efficacy of carbaryl, monocrotophos and leptophos each applied at two doses and in 3 spray schedules of 3, 4 and 5 sprays respectively at fortnightly interval and two applications of naphthalene acetic acid against the pest complex and the leaf curl of chilli and (b)

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to determine the rate of dissipation of carbaryl and monocrotophos applied as per above schedule on leaves and fruits of chilli and the waiting period to be elapsed between the last spray and the consumption of fruits.

The field experiment was carried out in factorial randomized block design at the Research Farm of Banaras Hindu University, Varanasi, during the crop seasons of 1976-77 and 1977-78. The insecticidal treatments consisted of carbaryl, monocrotophos and leptophos (main treatment) each at two doses (sub-treatment) covering normal recommended dosage (carbaryl, 1 kg a. i./ha; monocrotophos, 300 g a. i./ha; leptophos, 350 g a. i./ha) and the twice of that. For comparison, NAA @ 20 ppm was also induced. Each insecticide was applied in three spray schedules, comprising of 3, 4 and 5 repeated sprays, respectively. Thus, the total number of treatments including control were 20.

The insect population count was started 24 DAT and continued thereafter 24 hours prior and 72 hours after each treatment. The plants affected by leaf curl were also counted the same time. Residues of carbaryl were determined colorimetrically by method provided by Union Carbide of India (30 U1A15-7) and those of monocrotophos, by enzyme inhibition method suggested by Ciba Geigy of India as well as by bioassay using *Drosophila melanogaster* M. in leaves and fruits of chilli. The findings of the investigation are summarised below in brief :

1. Pest complex during the two crop seasons comprised of thrip, *Scirtothrips dorsalis* Hood and aphid, *Aphis gossypii* Glover.

2. Mean population distribution on the crop at fortnightly intervals indicated thrips to attain peak density in October and November (37.22 and 20.66 thrips/5 plants for the two seasons respectively) and to fall in successive months till February to less than 2.5 thrips/5 plants.

3. The aphid population showed two peaks; first in November (33.00 and 26.66 aphids/45 leaves for the two crop years) and the second in February and March (21.88 and 28.00 aphids/45 leaves for the two crop years).

4. Statistical analysis on effect of the treatments showed insecticide to be more toxic as evidenced by 72 hours post-treatment mortality of thrips and also, the lower mean thrip population on the crop, for the entire season; than control. Naphthalene acetic acid in these respects was at par with control. Carbaryl and monocrotophos were more toxic and recorded lower thrip population in the field than leptophos.

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Carbaryl and monocrotophos were equally effective to cause mortality and to afford check in mean thrip population except for 1977-78 where monocrotophos recorded lower population of thrips than carbaryl.

In general, higher dose of insecticides proved superior to lower dose to cause mortality, but the mean thrip population remained comparable at both doses. Thus, during 1976-77, monocrotophos at higher does (600 g a.i./ha) was more toxic to thrips as compared to the lower dose (300 g a.i./ha) and both doses of carbaryl (2 Kg and 1 kg a.i./ha) which did not vary significantly among themselves. However, during 1977-78 the higher dose of these two insecticides proved at per in efficacy and were superior to the lower dose.

Number of sprays forming the spray schedules did not affect the mean thrip population during the year 1976-77 but the mean population in 1977-78 was lower with 5-spray schedule than 3-spray schedule. Interaction effects among insecticide, dose and spray schedule were always nonsignificant.

5. The main effect of the treatments showed that monocrotophos caused higher aphid mortality than carbaryl. Both these insecticides were superior to leptophos. The mean aphid population remained statistically similar in monocrotophos and carbaryl treated plots. Monocrotophos treatment was superior to leptophos. The 72 hours mortality with different insecticidal treatments against aphid was in order of : monocrotophos @ 600 g a. i./ha> carbaryl @ 1 kg a. i. ha= monocrotophos @ 300 g a. i./ha> carbaryl @ 1 kg a.i./ha = leptophos @ 700 g and 350 g a.i./ha.

The insecticidal spray schedules did not show significant effect on the mean aphid population during both the years of trial. Among the treatments, monocrotophos @ 600 g a.i./ha sprayed 5 times was at per with all the treatments except leptophos @ 350 g a.i./ha sprayed 3 times (during 1976-77) or 3 to 4 times (during 1977-78).

6. Monocrotophos and carbaryl proved equally effective in reducing the leaf curl incidence and both were superior to leptophos. Although, the dose effect was nonsignificant for the year 1976-77, the higher dose of insecticidal treatments recorded lower leaf curl incidence as compared to the lower dose in 1977-78.

The 5-spray schedule recorded lower % plants showing leaf curl than the 3-spray schedule in 1976-77 and 3-spray or 4-spray schedules in 1977-78.

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The per cent affected plants were minimum with the higher dose of monocrotophos and carbaryl sprayed 4 to 5 times during 1977-78. There was no such distinction in 1976-77.

A significant co-efficient of correlation from 0.983 to 0.899 between mean population of insects from different treatments and the per cent plants showing leaf curl denoted a positive relationship between them.

7. Analysis of carbaryl and monocrotophos residues in chilli leaves and green fruits of marketable size indicated the recovery of carbaryl to be 86.73% in leaves and 90.09% in fruits with colorimetric method provided by Union Carbide of India Ltd., Bhopal. The sensitivity of the method was 0.99 ug/g for leaves and 0.47 ug/g for fruits. Monocrotophos recovered to the extent of 75.57% in leaves and 81.54% in fruits by bioassay using *Drosophila melanogaster*, with the calculated sensitivity of 0.065 ug/g for leaves and 0.03 ug/g for fruits. The recovery percentage of monocrotophos by enzyme inhibition method (Ciba-Geigy Method) was 78.94 in leaves and 84.71 in fruits with the sensitivity of the method being 0.07 ug/g for leaves and 0.05 ug/g for fruits.

8. Initial deposits of carbaryl on leaves during first three sprays were 57.41, 48.84 and 44.29 ppm at 1.0 kg a.i./ha and 80.28, 68.04 and 64.22 ppm at 2.0 kg a.i./ha. Dissipation studies of third spray recorded 5.67 and 6.44 days half life at the two doses, respectively. Values of initial deposits and half life on fruits recorded after third spray at both doses (12.60 ppm; 3.18 days at lower dose and 22.35 ppm; 3.06 days at higher dose) were lower than those on leaves.

The initial deposits of monocrotophos @ 300 g a.i./ha in lst, 2nd 3rd sprays were 24.95, 17.67 and 15.67 ppm on leaves. The corresponding values @ 600 g a.i./ha were 39.19, 28.49 and 23.34 ppm. The half life for 3rd application were 2.59 and 2.89 days at the two doses, respectively. Monocrotophos following 3rd spray left similarly, comparatively lower initial deposits of 8.14 and 11.42 ppm on fruits at the two doses with the respective half life of 1.40 and 1.83 days.

9. The initial deposits of these insecticides as in case of first three sprays decreased successively with 4th and 5th sprays also, both in leaves and fruits. The rate of dissipation decreased with the successive sprays. The highest half life of carbaryal was met in 4-spray schedules being 8.49 and 8.72 days in leaves and 3.99 and 6.38 days in fruits at the two doses used. The corresponding values for monocrotophos

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were lower being 3.32 and 3.64 days in leaves and 1.99 and 2.26 days in fruits. Residues in 5-spray schedule dissipated faster due to rains.

10. Waiting period for chilli fruits following application of carbaryl ranged from 0 to 0.68 days at 1.0 kg a.i./ha and 3.19 to 5.42 days at 2.0 kg a.i./ha in different spray schedules. This value for monocrotophos ranged from 7.86 to 10.12 days at 300 g a.i./ha and 10.90 to 12.77 days at 600 g a.i./ha.

11. The practical significance of these results has been suggested. The findings have been compared with the available literature and possible reasons for the deviations, if any, have been discussed.

BIOEFFICACY AND PERSISTENCE OF LINDANE AND QUINALPHOS AGAINST INSECT PESTS OF OKRA AND BRINJAL AND THEIR RESIDUES IN FRUITS

Rakesh Kishore Sup. : *Dr. Lallan Rai*

The present investigations were conducted to evaluate the bioefficacy and persistence of lindane 20 e. c. and quinalphos 25 e. c. against aphids and jassids attacking okra and brinjal crops during various seasons. The initial deposits and residues in/on fruits were also worked out. All the trials were conducted at Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The crops of okra were taken during summer and rainy seasons, while brinjal crops were grown during winter and summer seasons. The crops were treated with lindane 20 e. c. at the rate of 1.0 and 2.0 kg a. i./ha and quinalphos 25 e. c. at the rate of 0.3125 and 0.6250 kg a. i./ha. Spraying was done twice at the interval of 15 days, starting from the first fruit set.

To evaluate the effectiveness of all the treatments in controlling aphids and jassids, in each plot 10 plants were selected randomly and counts were made on leaves at varying intervals after the treatment.

For the assessment of persistence toxicity, leaves were plucked from treated as well as untreated control plots and were brought into the laboratory. These leaves were subjected to the insect release at the rate of 10 insects/leaf/petridish. Mortality counts were taken after 25 hours continuous exposure at $27 \pm 1^{\circ}C$ temperature.

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Initial deposits and residues were quantitatively estimated by employing two methods for each insecticide. Lindane residues were estimated by colorimetric and microbioassay methods, whereas, quinalphos residues were estimated by colorimetric and Ch E inhibition methods.

The findings of the experiments on all the aspects are summarised hereunder :

(i) It was revealed that aphid and jassid population can be suppressed by applying the treatments included in the present investigation. The order of efficacy alongwith doses (kg a. i./ha) of the treatments in the parantheses was : lindane (2.0) > quinalphos (0.6250) > lindane (1.0) > quinalphos (0.3125).

(ii) Taking into consideration the LT_{50} and PT values the order of persistent toxicity of all the treatments alongwith doses in parantheses (kg a. i./ha) was : lindane (2.0) > quinalphos (0.6250) > lindane (1.0) > quinalphos (0.3125). Results obtained for persistent toxicity were in confirmation to the results obtained in the present investigation under field conditions for the control of aphid and jassid population.

(iii) Results pertaining to the residues in/on okra and brinjal demonstrate that waiting periods very much depend upon the dose of insecticide applied and the seasons during which crops have been taken.

On the basis of results obtained it can be recommended that application of lindane 20 e. c. at the rate of 1.0 and 2.0 kg a. i./ha on okra crop should be followed with a waiting period of 5 days (summer season). Whereas, rainy season crop would require a waiting period of 4 to 5 days for both the doses of lindane. However, okra fruits, treated with either dose of lindane, can be consumed safely on the day of spray provided they should be washed and cooked properly.

The fruits of okra treated with quinalphos 25 e. c. at the rate of 0.3125 and 0.6250 kg a. i./ha need a waiting period of 4 and 5 days respectively, during summer season. Whereas, for rainy season crop a waiting period of 5 days should be observed, using either dose of quinalphos. However, washed+cooked fruits of okra treated with quinalphos can be consumed on 3rd day after the spray.

A waiting period of 3 and 4 days has been worked out in the case of brinjal crop with lindane 20 e. c. treatments at the rate of 1.0 and 2.0 kg a. i./ha, respectively (winter season). During summer

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season, waiting period of 2 and 3 days was found sufficient for the lindane treatments at the rate of 1.0 and 2.0 kg a. i./ha. Washing alone was found adequate for the safe consumption of fruits on the day of treatment with the lower application rate of lindane, washed fruits can be consumed on 3rd day after the spray.

The brinjal crop treated with quinalphos 25 e. c. at the rate of 0.3125 and 0.6250 kg a. i./ha should be followed with a waiting period of 5 days, before the consumption of fruits during either season. On treating the crop with both the doses of quinalphos a waiting period of 3 days was found necessary before the consumption of washed and cooked fruits.

AN ECOLOGICAL STUDY OF WHITE GRUBS IN VARANASI AND MIRZAPUR DISTRICTS OF EASTERN UTTAR PRADESH

Paras Nath Sup. : *Dr. Janardan Singh*

The thesis embodies the results of investigations conducted on "An Ecological Study of White Grubs in Varanasi and Mirzapur Districts of Eastern Uttar Pradesh". The studies were made during 1977 to 1980 at different fields situated in Varanasi and Mirzapur districts of Eastern Uttar Pradesh with the following objectives :

(1) To identify the pockets of white grubs in Varanasi and Mirzapur districts of Eastern Uttar Pradesh.

(2) To study the population dynamics of white grubs in sugarcane, groundnut, and wheat fields

(3) To know the spatial distribution pattern of the immature and mature stages of white grubs in sugarcane field.

(4) To record the frequency and dominance of lamellicorn scarabaeid beetles on light trap.

The findings of above aspects of studies are summarised below :

(1) The results of the survey conducted to investigate the white grubs infested pockets and qualitative composition have been recorded. Leaf-chafers group includes 3 sub-families, i. e., Melolonthinae Rutelinae and Dynastinae representing 8,8 and 3 species in each sub-family, respectively. Whereas, scavangers group has 5 sub-families, i. e., Coprinae, Aphodiinae, Geotrupinae, Hybosorinae, and Orphiinae having 11, 2, 1, 1, and 1 species in each sub-family, respectively. Leaf-

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chafers group has been recorded as a very serious pest of sugarcane, groundnut and ornamental lawns in this locality.

(2) The observations were made on the population dynamics of white grubs in sugarcane, groundnut, and wheat fields in different localities of Varanasi and Mirzapur districts of Eastern Uttar Pradesh. The white grubs associated with these three crops belong to 3 sub-families, i. e., Melolonthinae, Rutelinae, and Dynastinae having 8, 8, and 2 species, respectively. The study reveals that the eggs were maximum during June followed by July in sugarcane fields ; whereas in groundnut, it was maximum during July followed by August. The peak period of the grubs activity was in August followed by September in all the six surveyed localities. The sugarcane crop harboured more population than groundnut crop. The wheat crop, which was sown after harvesting the sugarcane and groundnut, did not show any alarming damage symptoms by the grubs. The pupal density was maximum in the month of April in the sugarcane and wheat fields. Pupal stages were recovered only during March to May. The adult beetles of white grubs were recorded during July, August, September, and April, May, June in sugarcane fields ; whereas during July, August September from groundnut and April and May from wheat fields.

The parasites associated with white grubs were *Scolia* sp. and the pupae and adult beetles were parasitized by the mesostigmatid mites. The predators like, ants, spiders (*Oxyopes pandae* and *Thomisus* sp.), lizzards (*Calotes versicolor* and *Hemidactylus flavivirdis*), toad (*Bufo melanosticus*), birds (*Corvus splendens, Acridotheres tristis* and *Columba livia*), stray dog (*Cuon alpinus* Pallas) and stray cat (*Felis constantina* Forster) were seen feeding either at grub stage or adult stage or both stages of white grubs.

The study made on the general bionomics reveals that these beetles start emerging after first monsoon shower in between 7 to 7.30 P. M. Mating and feeding took place on the adult host plants, i. e., 'Babul' (*Acacia arabica*), 'Neem' (*Azadirachta indica*) and rose (*Rose* sp.) in this region. Eggs were laid freely in the soil. The first instar grubs were feeding on the organic matter ; whereas 2nd and 3rd instar grubs, on the roots of the several rainy season crops, i.e., sugarcane, groundnut, sunhemp, sesamum, sorghum, pearlmillet, black gram, green gram and pigeon pea. Pupation took place inside the earthen cell and adult beetles started emerging just after first monsoon rain during June.

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The fresh and dry biomass of the grubs were recorded. Fresh and dry biomass increase with the increase in age and body size of the grubs. The pupal biomass was always lesser than the grub biomass of the same species. The minimum biomass was recorded during June, and it increases during later months being highest during January in sugarcane and wheat fields at village Thatara ; October in sugarcane and November in groundnut at village Tikari ; December in groundnut at village Bahadurpur ; November in groundnut at Chandauli ; February in sugarcane and November in groundnut at Majhawa Taras ; and January in sugarcane and December in groundnut at village Dharammalpur. The pupal biomass was always greater during April month at all the sites during both the years.

(3) Studies were made to record the spatial distribution pattern of different stages of white grubs in sugarcane field at Majhawa Taras site. The distribution was confirmed by different statistical parameters :

(i) Detection of aggregation by using frequency distribution,
  (a) Method of moments by using approximate value of $\hat{K}$,
  (b) Method of maximum likelihood by using more accurate value of $\hat{K}$.
(ii) Statistic U and Statistic T tests for agreement with a negative binomial distribution.
(iii) Indices of dispersion :
  (a) Index of dispersion ; variance mean ratio as a measure of dispersion.
  (b) Coefficient of dispersion—to measure the distributional pattern.
  (c) Morisita's indices of dispersion—as an index of distribution pattern.
  (d) Cole's index of dispersion—measure of dispersion pattern.
  (e) Exponent $\hat{K}$—as in index of dispersion.
(iv) Variance-mean relationship—detection of distribution pattern.

Studies on the micro-distribution of white grubs in tropical sugarcane field indicate that the distribution of white grubs follows negative binomial pattern which indicates clumped or aggregated nature of its population. Different types of indices of dispersion, used in the present investigation also confirmed the aggregated pattern of distribution of different stages of white grubs. Observations were also recorded on the vertical distribution of different stages of white grubs, and most of the stages were recovered from the top 20 cm of the soil. Vertical distribution of different stages of white grubs varies during

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different months, which was supposed to be due to the micro-environment of the soil.

(4) The observation recorded through light trap reveals that the scarabaeid beetles attracted to light trap belong to 8 subfamilies having 27 common species and 7 as occasional emerger species at village Nuayne and Government Farm, Chandauli.

The sub-family Coprinae constituted the major portion followed by Melolonthinae, Geotrupinae, Dynastinae, Hybosorinae, Aphodiinae, and Rutelinae at village Nuayne; whereas at Government Farm, Chandauli, Coprinae headed the group followed by Geotrupinae. Melolonthinae, Dynastinae, Hybosorinae, Aphodiinae, and Rutelinae. The lamellicorn leaf-chafer beetles recorded higher catch in the month of July followed by August, June, September, and October, except in case of Melolonthinae during 1978-79 and Rutelinae during 1979 which recorded more population in June than August at village Nuayne. Similar pattern was followed at Government Farm, Chandauli, with a little change where Dynastinae and Melolonthinae followed the similar emergence pattern as in case of Melolonthinae of village Nuayne. Coprinae, Aphodiinae and Geotrupinae beetles recorded highest population in the month of July followed by August, September, June, and May months. *Hybosorus* sp. of the sub-family Hybosorinae was maximum in the month of August followed by July, June, September, and May; whereas *Aphodius insularis* of the sub-family Aphodiinae was maximum in the month of August followed by July during 1978. *Apogonia ferruginea* was collected maximum followed by *Apogonia uniformis*. *Autoserica insanabilis* was very poorly represented at both the sites. The other 3 species were collected in the order of *Schizonycha ruficollis* > *Autoserica nathani* > *Apogonia roucca* except at Government Farm, Chandauli, where *Autoserica nathani* recorded more population than *Schizonycha ruficollis*. During 1979 at both the sites, total catch of *Apogonia roucca* was more than *Schizonycha ruficollis*. Among the Rutelinea beetles, *Adoretus limbatus* was trapped maximum in number at both the sites during both the years. The total catch of other species is in following descending order : *Anomala ruficapilla* > *Adoretus versutus* > *Anomala bengalensis* > *Adoretus decanus* > *Anomala dorsalis* var. *fraterna* > *Adoretus lasiopygus* > *Anomala dorsalis* during 1978 and 1979 at Nuayne light trap. At Government Farm, Chandauli, these were in the order of *Anomala ruficapilla Adoretus decanus Adoretus versutus Anomala bengalensis Anomala dorsalis* var. *fraterna Anomala dorsalis Adoretus lasiopygus* during 1978 and 1979. An undetermined species of the sub-family Dynastinae recorded maximum catch than *Dyscinetus*

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trachipygus during both years at both the sites. Among 8 species of Coprinae beetles, *Onthophagus* sp.2 was recorded maximum followed by *Onthophagus quadridentatus, Onthophagus bonasus, Onthophagus cervus, Onthophagus dama, Onthophagus* sp. 1, *Onitis philemon* : and the least catch was represented by *Copris* sp. during 1978 and 1979 at both sites, except in case of *Onthophagus* sp. 1 which recorded more population than *Onthophagus cervus* but lesser than *Onthophagus bonasus, Aphodius insularis, Bolboceras* sp.; and members of *Hybosorus* sp. were more in population during 1978 than 1979 at both the sites. The total catch of *Hybosorus* sp. was greater at Chandauli than village Nuayne light trap. Most of the beetles were captured maximum in July followed by August, June, September, October, and May though there were few exceptions also. The relative abundance values follow the trend of monthly total catch of beetles. The frequency of emergence on light trap catches were recorded, and it reveals that Scarabaeoidea beetles recorded highest frequency of emergence at Government Farm, Chandauli, in comparison to village Nuayne light trap during both the years. Among the 3 sub-families of leaf-chafer group, Melolonthinae recorded highest frequency followed by Dynastinae and Ruetelinae during both the years at both the sites, except 1978 at Government Farm, Chandauli where Rutelinae recorded slightly greater frequency than Dynastinae. Scavanger beetles recorded higher frequency than leaf-chafer group. The frequency of emergence of scavanger group was higher at Government Farm, Chandauli, in comparison to village Nuayne.

The percentage composition of different species of Scarabaeoidea fauna based on light trap catches was also worked out. A two way classification was performed on the basis of frequency and relative abundance. Different statistical methods were applied to detect the pattern of emergence and were observed that the emergence pattern of these Scarabaeoidea beetles were irregular. To measure the effects of abiotic factors on their emergence pattern, multiple correlation coefficient (R) was analysed ; and it was found that these coefficients were significant at 1% probability level, except in few species. The value of coefficient of determination (R^2) high-lights the joint contribution of abiotic factors on the light trap catches of Scarabaeoidea beetles. To detect the effects of individual abiotic elements, simple and partial correlation coefficients were determined. These coefficients reveal that rainfall and relative humidity play major role, i.e., positively significant in determining the emergence pattern of these beetles. But temperature and sunshine hours were negatively correlated in most of the species when simple correlation was considered.

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GENETICS & PLANT BREEDING

GENETICS OF YIELD AND YIELD TRAITS OF INDUCED MUTANTS IN WHEAT *(TRITICUM AESTIVUM* L.)

Sheo Pratap Singh Sup. : *Dr. R. M. Singh*

The present study was aimed to characterize the nature and magnitude of genetic variances and gene effects, combining ability (variances and effects), heterosis and inbreeding depression in a 10×10 diallel non-reciprocal crosses using induced mutants of variety K 68 in bread wheat. The nine mutants (HUW DF_1, HUW DF_9, HUW DF_{12}, HUW HP_1, HUW HP_2, HUW W_{9-2}, HUW Br-1, HUW Br-3 and $C_3+12+13C$) were quite distinct from each other with regard to a number of traits and behaved as true breeding homozygous lines. The initial variety K 68 was also included in the diallel analysis. The diallel set of 10 parents comprising of 45 F_1s, 45 F_2s and 45 each of the back crosses were sown during the Rabi 1980-81 in a Randomized Block Design with three replications. Data were recorded on six characters, namely, plant height, number of effective tillers per plant, spike length, number of grains per spike, 1000-grain weight and grain yield per plant.

Plot means were used for the analyses. The graphic and component analysis of diallel cross were carried out by the methods of Jinks (1954) and Hayman (1954), respectively. Combining ability analysis was done according to Griffing (1956), Model I and Method II. Generation mean analysis of gene effect was performed following Hayman (1958) and Jinks and Jones (1958).

The means sum of squares due to genotypes in F_1s, F_2s, B_1s and B_2s were significant for all the six characters. The validity of the diallel hypothesis was tested by 't^2' test (Hayman, 1954). The 't^2' estimates were non-significant for all the characters except grain yield per plant suggesting fulfilment of assumptions of diallel analysis.

The regression coefficient (b) of the regression of Wr on Vr significantly deviated from zero for all the characters under study indicating that the estimates obtained through graphic analysis would be valid. However, epistasis was revealed for spike length, number of grains per spike and grain yield per plant (F_1 and F_2) and 1000-grain weight (F_2).

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The graphic analysis revealed partial dominance for plant height (F_1 and F_2) and 1000-grain weight (F_2). For the remaining characters in both (F_1 and F_2) diallel sets, over-dominance type of gene action was noticed.

The additive component ($\hat{D}$) of the genetic variance was significant for all the characters in both the diallel sets, except grain yield per plant (F_1 and F_2). The dominance components $\hat{H}_1$ and $\hat{H}_2$ were also significant for all the characters in both the populations except $\hat{H}_1$ component for 1000-grain weight in F_2. The non-additive component $\hat{h}^2$ was negatively significant for number of grains per spike in F_2, for the remaining characters, except plant height and number of grains per spike (F_1) and effective tillers per plant (F_2), it was positive and significant in both the populations.

The proportions of the components of genetic variance were also estimated. The proportion $\hat{H}_2/4\hat{H}_1$ was close to the expected value of 0.25 and indicated symmetrical distribution of positive and negative alleles among the parents for plant height (F_2), 1000-grain weight (F_1 and F_2) and grain yield per plant (F_1). The proportion of dominant to recessive genes (KD/KR) exhibited an excess of dominant genes in the inheritance of most of the characters. The average degree of dominance indicated over-dominance for all the characters in both the populations except plant height (F_1 and F_2) and 1000-grain weight (F_2). The proportion $\hat{h}^2/\hat{H}_2$ which indicates the number of dominant genes or group of genes controlling traits revealed that one to four genes/group of genes were involved in the inheritance of different characters.

The heritability in narrow sense was more than 60 per cent for plant height and 1000-grain weight in F_1 and more than 50 per cent for plant height and number of effective tillers per plant in F_2. The spike length and grain yield per plant in F_2 exhibited heritability estimates to be less than 16%. The grain yield per plant exhibited poor heritabiliiy estimates in both F_1 and F_2 populations.

The analysis of variance for the combining ability revealed highly significant GCA and SCA variances for all the characters. The ratio σ_g^2/σ_s^2 was less than one for all the characters except plant height, indicating that the proportion of variance σ_s^2 was greater than the variance σ_g^2. The proportion σ_A^2/σ_D^2 indicated that the additive genetic variance was greater than the non-additive genetic variance for plant height and 1000-grain weight in F_1 and F_2.

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In general, graphic, component and combining ability analyses were in agreement to each other and it was concluded that both additive and nonadditive variances are important in controlling yield and yield contributing traits in wheat. However, the relative magnitude of two components varied from character to character and population to population.

The mean performance of the parents for different characters was at par with the general combining ability effects, Parents, namely, HUW DF_9, HUW Br-3, K 68 and HUW DF_1 were the best general combiners for grain yield per plant, Among the good general combiners for yield, HUW Br-3 was also a good general combiner for spike length and number of grains per spike. Most of the mutant lines showed significantly poor GCA effects for 1000-grain weight against variety K 68.

In general, crosses which showed significant SCA effects included one good and other poor general combiner. Crosses HUW $DF_{12} \times C'_3 +$ 12+13C, HUW $HP_1 \times$ K 68, HUW $DF_9 \times$ K 68; HUW $HP_2 \times$ K 68 exhibited significantly desirable SCA effects for grain yield per plant (F_1). The cross HUW $DF_9 \times$ HUW Br – 3 second in order of merit of SCA effects for grain yield per plant exhibited more than 20% heterosis over better parent for 1000-grain weight. Among the five best crosses showing higher heterosis for spike length, number of grains per spike and grain yield per plant, K 68 was one of the parents.

The *per se* performance of the crosses were not related with their SCA effects for most of the characters in F_1 and F_2 populations. It was observed that the five best crosses in the F_1 and F_2 analyses did not include the same parents. However, the crosses HUW Br-$1 \times C'_3 +$ 12+13C for plant height and HUW $DF_9 \times$ HUW Br-3 for number of grains per spike showed higher SCA effects in both F_1 and F_2 analyses.

The heterosis for tallness ranged from 1.48 to 18.35%, whereas for dwarfness it was maximum for the cross HUW Br-$1 \times C'_3 +$ 12+13 C (−17.82%). The inbreeding depression for plant height ranged from −43.37 to 18.16%. The cross HUW $DF_1 \times$ HUW HP_1 exhibited highest heterosis (39.27%) for number of tillers per plant. The best heterotic cross for both spike length and number of grains per spike was HUW $HP_1 \times$ K 68. The cross HUW $DF_9 \times$ HUW DF_{12} was the best heterotic cross for 1000-grain weight.

In most of the cases, crosses showing high heterosis/SCA effect for grain yield per plant had higher heterosis/SCA effect for at least one of the three components of yield i. e., number of grains per spike, number of effective tillers per plant and 1000-grain weight.

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The inbreeding depression for grain yield per plant was high for the crosses exhibiting higher heterosis. Among the five best crosses exhibiting low inbreeding depression for spike length, the inbreeding depression was nonsignificant for four crosses, whereas, for remaining characters inbreeding depression was of noticeable amount for most of the crosses. In general, cross showing higher heterosis exhibited higher inbreeding depression for the character under study.

In generations mean analysis, around 75% of the total crosses derived from 10 × 10 diallel, had digenic interactions for plant height, number of effective tillers per plant, number of grains per spike and grain yield per plant and around 60% for spike length and 1000-grain weight. The percentage of interacting crosses exhibiting significant additive gene effects for different characters ranged from 25% (for spike length) to 43% (number of effective tillers per plant and 1000-grain weight), whereas, for dominant and epistatic gene effect it was from 25% (spike length for $\hat{h}$ and $\hat{j}$) to 77% (number of effective tillers per plant for $\hat{h}$, grain yield per plant for ($\hat{1}$). In majority of the cases, the percentage of interacting crosses exhibiting significant $\hat{h}$, $\hat{i}$, $\hat{j}$ and $\hat{l}$ components were more than 50% except for 1 component in case of spike length, 1000-grain weight and plant height and $\hat{j}$ component in case of grain yield and number of effective tillers per plant.

Among the epistatic components, $\hat{i}$ and $\hat{i}$ components, were more important than additive × dominance component $\hat{j}$ for number of effective tillers per plant, spike length and grain yield per plant, whereas, plant height, number of grains per spike and 1000-grain weight exhibited the importance of additive × dominance $\hat{j}$ component over both additive × additive and dominance × dominance epistatic components.

Based on various estimates certain recommendations have been made for genetic improvement of wheat population. For simultaneous effective utilization of both additive and nonadditive genetic variance, some sort of recurrent selection procedure, intermating of the desirable segregates in the early generations have been suggested. However, judicious utilization of particularly nonadditive gene action in wheat, a predominant cereal crop of the world, should await availability of commercially feasible male fertility restoration and efficient pollen transfer device.

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CHARACTERISATION OF GENE EFFECTS AND THEIR IMPLICATION IN RICE (*ORYZA SATIVA* L.) BREEDING

Kehar Singh Kanwal Sup. : *Dr. R. M. Singh*

The present investigation was carried out to characterise the nature and magnitude of genetic variance and gene effects and combining ability (variances and effects) in a diallel involving nine divergent gene pools in rice, selected from different topologically distinct clusters arrived at by multivariate analyses.

In diallel study, two critical assumptions, absence of epistasis and independent distribution of genes among the parents are likely not to be fulfilled. Therefore, four sets of Triple Test Cross families were generated to account for interallelic interaction.

The first set of experiments comprised hundred populations, which included (i) 74 indigenous collections having about ten dwarfs and semi-dwarfs, (ii) improved plant types from IRRI, CRRI AICRIP and Indica-Japonica hybrid from Malaysia, (iii) commercially grown cultivars endemic to the area, were grown in a replicated trial during June-December 1979. Characters of fitness and physiological efficiency were scored at appropriate developmental stages of plant growth. These included, (i) days to flowering, (ii) days to maturity, (iii) effective tillers/plant, (iv) plant height, (v) panicle length, (vi) panicle weight, (vii) number of grains/panicle, (viii) length of grain, (ix) breadth of grain, (x) L/B ratio, (xi) test weight and (xii) seed yield per plant.

The populations differed significantly with regard to characters studied individually (Analysis of variance, Fisher, 1918) and had a marked divergence when subjected to Wilk's Lamda criterion for simultaneous test of significance (V-statistics being highly significant). D^2-statistics was used for assessing the genetic divergence between the populations. Except a few, all D^2 values were significant. Applying Tocher's method, populations were grouped in 9 clusters. Based on 12 characters canonical analysis almost confirmed the clustering pattern, composition and relative disposition, obtained by D_2-statistics. The first two canonical roots together shared 80% of the variation. By mere coincidence the sequential F-ratio test in non-heirarchical Euclidean cluster analysis was also found highly significant for nine cluster data structure. But, the clustering pattern differed from that arrived at by above two statistics. The results obtained by cluster analysis, however, seemed quite appealing, satisfying a *priori* expectations of investigators. The superior sensitivity of this method was

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further confirmed when data of 4 Triple Test Cross families were grouped by these three multivariate analyses. The use of this method in plant breeding and genetics, for the study of genetic divergence and classification of genotype and its superiority over the other two widely used techniques is explained. The genotypes from different origins clustered together in six out of nine cases confirming the view that genetic-geographical diversity may not be related. The analysis revealed that characters span of maturity, plant height, panicle weight, kernel/panicle and seed size were the potent forces contributing towards divergence in rice genome.

The second experiment constituted a diallel analysis (F_1s and F_2s) involving nine genetically divergent gene pools, namely, Samsfaroz, Pawanpir, Dhaneshwar, Mahsuri, IR-36, Sonabhusi MPR-7, Anandi and Badshaw Pasand. The progenies were evaluated for fourteen characters. Plant basis observations were scored for effective tillers, plant height, panicle length, spikelets and kernels per panicle, test weight and seed yield per plant, other characters, namely, days to flowering, maturity, kernel L/B ratio, amylose content, gelatinization temperature (Alkali spreading and clearing values) and protein content was studied on plot basis.

Based on plot means, the progenies differed significantly for all the characters in both the populations.

The combining ability analysis following Griffing's (1956) method 2, model I for these reference populations indicated that mean squares for both main effects (GCA) and interactions (SCA) were highly significant in both the generations. Estimates of gca variances were much smaller than their corresponding sca variances, except days to flowering (F_1), test weight, kernel L/B ratio, gelatinization temperature and protein content (F_1 and F_2) where, however, the magnitude of gca variances were in higher order implying the importance of additive gene action. The results remained consistant over generations. The ratio of additive genetic variance ($2\sigma_g^2$) to dominance variance σ_s^2) revealed nonadditive type of gene action for effective tillers, spikelets and kernel/panicle and seed yield/plant in both the generations. For plant height and panicle length, however, this type of gene effects were revealed only in segregating generation. For rest of the characters the ratio suggested the importance of additive gene actions. Further, the ratio ($2\sigma_g^2/2\sigma_g^2+\sigma_s^2$) determined the predictability for protein content, test weight, kernel L/B ratio and gelatinization temperature because for these characters, the value tended to approach unity suggesting interplay of additive gene action for the characters.

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Combining ability effects of the parents were associated with their *per se* performances in case of more than 50% of the characters. Parent Mahsuri was the best general combiner for yield and yield traits followed by Dhaneshwar. For quality traits and nutritional aspect, the sources, Samsfaroz, Sonabhusi and Badshaw Pasand were identified as lines with promise. In some cases high/high crosses performed well, while performance of high/low cross combinations were unpredictable suggesting the importance of allelic and nonallelic interactions. Generally crosses involving diverse parents showed high estimates of sca effects. The usefulness and long term potentialities of each line and utility value of the crosses with other types have been assessed and discussed.

The graphic and component analyses using plot means were carried out by the methods of Jinks (1954) and Hayman (1954) respectively.

The 'Z^2' tests were non-significant for all the characters except for effective tillers and kernel L/B ratio in F_1 generation indicating uniformity of Vr, Wr, values for most of the characters. The regression line significantly deviated from unit slope in case of effective tillers, panicle length, kernel/panicle and seed yield in F_1 generation. The significant deviation of regression from unity indicated presence of epistasis and/or correlated gene distribution among the parents.

Except for tillers per plant (F_2), amylose content (F_1), spikelets and kernels per panicle (F_1 and F_2) and seed yield (F_1 and F_2) where the negative values of Wr intercepts indicated overdominance which might generally be owing to epistatic gene action, graphic analysis revealed complete to partial dominance for all other characters. The order of dominance in the parents for each character and effect of heterozygosity-homozygosity was of immense significance.

The estimates of additive genetic variance were significant for all the characters except effective tillers (F_1) and seed yield (F_1 and F_2). The non-significance of additive genetic variance (D) explains the low values of heritability. Heritability being the fraction of the selection differential, true heritability should be accompanied with the same magnitude of expected values of advance through selection.

The nonadditive components (H_1 and H_2) were significant for all the populations for fourteen characters. The magnitude of H_1 was greater than that of H_2 in all the characters over generations indicating the predominant role of nonadditive gene actions. The

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magnitude of H_1 and H_2 was, however, in order in most of the cases indicating symmetrical distribution of genes. However, for plant height, spikelets and kernels per panicle, the order seemed little disturbed because of probably asymmetrical distribution of genes. The pattern of order was confirmed by the ratio $H_2/4H_1$. Positive significant h^2 values for most of the characters are supposed to be owing to the positive mean direction of dominance. The negative values of F for effective tillers (F_1) and protein content (F_1) indicated greater proportion of negative recessive genes. (However, values were statistically non-significant). For all other characters presence of dominant positive genes was indicated.

Non-significance of F values for many characters suggested ambidirectional dominance. Environmental component (E) was found significant only in case of spans of maturity (flowering and senescence) which indicated the masking effects of environment. Occasionally, the nature of gene actions might be considerably modified by the environment (flowering, maturity and plant height being the most sensitive traits to be affected by such modifiers).

The estimates of degree of dominance $(H_1/D)^{0.5}$ were higher than unity for effective tillers/plant, panicle length, spikelets/panicle, kernels/panicle, amylose content and seed yield/plant in F_1 generation. in F_2 generation for all the characters the value exceeded unity. The value above than unity speaks for overdominance.

The ratio K_D/K_R which gives the relative values of dominant and recessive genes was less than unity for effective tillers and protein content in F_1 generation. For all other characters in F_1 and F_2 generations, the ratio exceeded unity indicating preponderance of dominant allels among the parents. The h^2/H_2 ratio which is an estimate of group of dominant genes controlling character, indicated 1 to 2 effective factors for flowering, maturity, spikelets and kernels/panicle and seed yield, invariably found depressed for most of the characters probably due to correlate gene distribution among the parents and cancellation effect of positive and negative genes.

Estimates of heritability in narrow sense was high and consistant over generations for plant height and test weight, indicating substantial proportion of additive genetic variance in phenotypic expressions. For all other characters the values of narrow sense heritability were invariably low, being lowest in case of seed yield/plant. The values were inconsistant over generations indicating preponderance of nonadditive gene actions for the trait.

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The third experiment embraced four sets of Triple Test Cross families. Thirty families each from a cross of Anandi/MPR-7, Samsfaroz/Pawanpir, Anandi/IR-36 and Madrasi/IR-36 were generated using divergent ten lines in each case. The data of Triple Test Cross families were analysed by the techniques of Kearsey and Jinks (1968), Jinks *et al.* (1969), Jinks and Perkins (1970) and Ketata *et al.* (1976) for the estimation of epistatic effects. Further additive-dominance model of Kearsey and Jinks (1968) was adopted to the same data assuming no epistasis.

Significant estimates of epistasis for all the characters except test weight in set IV among the four Triple Test Cross progenies were observed. Partitioning of epistasis item revealed that the modification of additive effects (i type epistasis) was not significant for the characters days to flowering, panicle length and test weight in experiment I and amylose content in experiment III, whereas modifications of dominance deviations (j and l type epistasis) were found insignificant only for test weight in experiment IV. Absence of i type epistasis for the character indicated that overall epistasis is relatively a minor component for the characters. Because of the bias caused by the epistasis no precise conclusion could be drawn about the relative importance of three components.

Variances due to sums and differences were highly significant for all the characters in all the four set of experiments. Component D (additive) and H (dominance) were significant for all the characters except for kernel L/B ratio and gelatinization temperature.

The implications of the present findings for exploiting efficient breeding plans aiming to improve rice populations have been elaborated and a set of recommendations have been made for efficient handling of breeding populations of rice.

EFFECTS OF CERTAIN MUTAGENS IN RELATION TO PRESOAKING DURATIONS IN WHEAT

Bhupendra Narayan Singh Sup. : *Dr. R. M. Singh*

The present investigation was aimed to study the biological and mutagenic effects of different mutagens viz. gamma-rays (20 Kr), EMS, HA and a potent herbicide 2,4-D singly and also in combination with gamma-rays through different seed presoaking durations in bread wheat (*Triticum aestivum* L.) var. K 68. Dry seeds (10.2% moisture) were

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irradiated with 20 Kr dose of gamma-rays and then fresh seeds and irradiated seeds were soaked in petri-dishes on moist blotting paper for 1, 6 and 12 hrs and then treated with EMS (0.05 M), HA (0.5 M) and 2,4-D (200 ppm) for 6 hr. To study chemosensitivity parameters, the observations were recorded on germination, plant survival, seedling height, pollen sterility, chromosomal abnormalities during meiosis and chlorophyll chimeras in M_1 generation. The genetic effects were determined by study of mutation frequency and spectrum in M_2 and induced polygenic variability in M_2 and M_3 generations and confirmation of desirable morphological mutants in M_4 generation.

Mutagenic treatments separately and in combination with gamma-rays caused reduction in germination, seedling height, plant survival and pollen fertility. The presoaking duration of 12 hr followed by 6 hr falling in G_2 and S phases of cell cycle respectively showed most pronounced effect on the various attributes. Among individual mutagenic treatments gamma-rays was more effective in reducing germination, seedling height and plant survival, whereas, EMS (at 6 hr) was more effective in reducing the pollen fertility. The effect of gamma-rays with regard to different seed presoaking was more or less similar. The effect of 2,4-D was weak as compared to other chemical mutagens. Combination treatments (at 12 hr) were in general more effective than the individual treatments, the effect being greater in 20 Kr+EMS.

A number of meiotic chromosomal abnormalities viz. univalents, non-orientation, ring or chain of chromosomes at metaphase I, chromatin bridge, laggards, bridge+laggards at anaphase I and micronuclei at telophase I were recorded in the treated populations. Gamma-rays among the individual treatments was more effective in inducing cytological abnormalities than the EMS, HA or 2,4-D. Combination treatments were more effective than the single mutagenic treatments but the effect was less than additive in the treatments given separately. The effect of different seed presoaking durations was more or less comparable.

Chlorophyll chimeras in the form of white or yellow streaks of varying degrees were observed in individual treatments of EMS and HA and also in combination treatments of these chemicals with gamma-rays, while it was absent in gamma-rays and other treatments. EMS singly and in combination with gamma-rays produced chlorophyll chimeras at all the presoaking durations being maximum at 6 hr presoaking, whereas, HA alone and in combination with gamma-rays was

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only effective in producing chimeras at 6 hr presoaking duration. Combination treatments were, in general, superior than the individual treatments.

The result on chlorophyll mutation frequency and spectrum clearly indicated the significance of seed presoaking durations especially 6 hr which is related to the DNA synthesis phase followed by 12 hr i. e, G_2 phase of cell cycle. EMS was most effective among individual mutagenic treatments while combination treatments of gamma-rays with EMS followed by gamma-rays with HA were highly effective in increasing the M_2 chlorophyll mutation frequency and spectrum showing a synergistic effect.

The viable mutation frequency per 1000 M_3 plants was higher in the EMS among the individual mutagenic treatments. In general, combination treatments particularly gamma rays+EMS were more effective than the individual mutagenic treatments Highest frequency of viable mutations were produced by combinations of gamma-rays with EMS and 2, 4-D at 12 hr followed by 6 hr presoaking and with HA at 6 hr presoaking duration.

Mutation spectrum both chlorophyll and viable were wider in EMS among individual mutagenic treatments and combination treatments were more effective than the individual treatments particularly gamma-rays+EMS. Among seed presoaking durations, 6 hr presoaking followed 12 hr presoaking were effective in widening the spectrum of mutations.

Induced quantitative variation in respect of yield and its major components were studied in M_2 and M_3 generations treated with different mutagens singly or in combination at different seed presoaking durations.

The means of different quantitative characters showed significant differences in the treated populations. The means of the treated populations were both higher and lower than those of the controls depending upon the character and generation in question. In M_2 generation, characters viz 1,000-grain weight showed a general decrease in mean while others showed variable responses in both plus and minus directions than those of control mean values. However, in M_3 generation, characters viz. plant height, tillers/plant and 1,000-grain weight showed a general increase and seeds/spike exhibited a general decrease. Also, the shift in mean for most of the characters was greater in combination treatments than the individual treatments.

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The magnitude of range for various characters showed that the spreads of the mutagen treated populations exceeded those of the controls on either or both the sides.

The magnitude of coefficient of variability in treated population was generally higher as compared to the control for most of the characters in both the generations except 1,000- grain weight where higher C. V. values were observed in all the treatments than the control in M_3 and reverse was true in the M_2 generation. Tillers/plant, seeds/spike and yield/plant showed increased C. V. values than controls in both M_2 and M_3. Spike length showed increased C. V. values in M_2 and decreased C. V. values in M_3 except few combination treatments. Plant height showed variable response i. e., higher or lower C. V. values than the controls in both the generations.

The comparative study on the observed changes in mean and C. V. values in the mutagen treated populations of both M_2 and M_3 generations revealed that the mean values of plant height and 1,000-grain weight, in general, were lower in M_2 than the M_3, whereas, the mean values of tillers/plant and yield/plant were more in M_2 than the M_3. A variable response was observed for mean spike length and seeds/spike in both the generations. The values of C. V. in different treated populations declined from M_2 to M_3 generation for all the characters except plant height and spike length where variable response was observed. From practical breeding point of view, such increased variation assumes greater significance.

Polygenic variability was greater in magnitude in the combination treatments of 20 Kr + EMS and 20 Kr + HA especially at 6 hr and 12 hr presoaking durations for various characters studied in both M_2 and M_3 generations. For spike length and 1,000-grain weight, 20 Kr + EMS at 12 hr presoaking; for yield/plant, 20 Kr + EMS at 6 hr presoaking; for tillers/plant 20 Kr + HA at 6 hr presoaking were more effective whereas for plant height, 20 Kr + HA at 12 hr in M_2 and 20 Kr + EMS at 6 hr in M_3 generation and for seeds/spike, 20 Kr + EMS at 1 hr in M_2 and 20 Kr+ HA at 6 hr in M_3 generation were more effective treatments than others for producing positive mutations.

A number of desirable morphological mutants were screened in M_2 and M_3 generation. Cytological analysis of these mutations did not reveal any apparent chromosomal anomalies. Certain useful mutants, such as, mutants for earliness, dwarfness, high tillering larger test weight, disease resistance and higher grain yield per plant, were isolated which will be used in wheat breeding programme.

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GENETICS OF YIELD AND QUALITY TRAITS IN RAJMAH (*PHASEOLUS VULGARIS* L.)

Krishan Lall Vaid Sup. : *Dr. R. M. Singh*

Rajmah bean (*Phaseolus Vulgaris* L) commonly known as French bean is an important legume with a grain protein content of 18 to 38 per cent (Ortegad *et al.* 1974). The tender green pods of this crop are eaten as a delicious vegetable. Most of the reported work on this crop pertains to the chemical analysis and evaluation of its nutritive value. Little information is available on the genetics of this crop, therefore, the present investigations were aimed at the study of genetic variability, heritability, genetic advance, character association, selection indices, genetic divergence, stability and genetic control of yield, protein content and other morphological traits and nature of combining ability.

Hundred germplasm were collected from the main Rajmah growing area of India, which fall in the state of Jammu and Kashmir and Himachal Pradesh, other parts of the country and exotic sources. These germplasm lines were evaluated at three environment for the study of divergence, correlations and path coefficient analysis. Twenty eight collections from these were selected on the basis of *per se* performance and planted at six environments for the study of stability parameters by using Eberhart and Russel (1966) method. From amongst these twenty eight varieties used for stability, six parents on the basis of their performance were selected for making a diallel cross. The parents alongwith their F_1's and F_2's were grown in a randomized block design.

The data were recorded for days to flowering, days to maturity, plant height, branches per plants, pods per cluster, pods per plant, pod length, seeds per pod, 100-grain weight and yield per plant. In diallel analysis protein content in grain was also studied.

High genetic variability and heritability in broad sense were observed for hundred grain weight, plant height, days to maturity, days to flowering and pod number. It was moderate to high for grain yield, number of pods per cluster and pod length. Expected genetic advance was high for days to maturity followed by days to flowering and 100-grain weight. The values of genetic advance were not necessarily in agreement with those of heritability in broad sense.

The coefficient of genotypic and phenotypic variation was highest for plant height and number of pods per plant followed by these for grain yield and 100-grain weight.

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The range of variation was highest for number of pods followed by grain yield, number of branches, hundred grain weight and plant height.

Study of genotypic and phenotypic correlations showed that yield was significantly and positively correlated with all the traits except hundred grain weight and pod length.

From the path coefficient analysis pod number was observed to be most important yield contributing component and alone accounted for nearly two third of variation in grain yield through its direct effect. Direct effect of hundred grain weight was also important at both genotypic and phenotypic levels.

To have a further idea of relative value of these traits a discriminant function was constructed. This showed that selection for taller plant height and seed number alongwith more number of branches and pods can help in the improvement of yield in this crop.

Mahalonobis D^2 analysis was found to be very useful in classification of genetically divergent groups. In all nine clusters were formed. Cluster V was found to be widely distributed among 16 districts studied for germplasm collection. Next were clusters IV, III, VII and VI.

In creating divergence and classification of various clusters days to flowering, days to maturity, plant height and 100-grain weight were found to be the most important characters. With regard to first three characters, the germplasm groups were clearly demarcated into late maturity tall group and early maturity dwarf group. The small versus bold seed was not related with divergence for lateness and tallness.

Simla district in Himachal Pradesh and Srinagar district in Jammu and Kashmir were found to be the area where maximum divergence existed fo this crop.

From amongst twenty eight varieties chosen for stability analysis four were significantly high yielders but all of them had low stability of performance but luckily some high stability lines were average yielders. The stability of performance in grain yield was related with stability of performance of pod number and increase was not correlated with stability of grain yield and other components. In the present investigation six of these lines on the basis of their stability were chosen as parents in diallel crossing programme.

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In the combining ability analysis in 6 × 6 diallel cross, HUR-91 was found to be highest combiner for grain yield. This parent was also high combiner for tallness, late maturity, late flowering, pod number, pod length, seeds per pod and hundred grain weight.

Amongst the crosses, HUR-9, HUR-67, HUR-9 × HUR-87, and HUR-37 × HUR-91 were found to be having high specific combining ability effects. However, high specific combining ability effects were retained for grain yield only in HUR-9 × HUR-67 in F_2 generation.

For protein content HUR-9 and HUR-37 were high combiner in both the generations.

The specific combining ability effects were largely unfixable for most of the traits.

The estimates of components of genetic variance revealed that additive × additive gene effects were important in inheritance of all the traits. Additive gene effects were more important of traits like days to flowering the plant height in F_1, while for yield per plant, number of branches, number of pods, number of seeds per pod, seed protein and pod length the non-additive effects were more important. In F_2 analysis only for plant height, both the effects were equally important otherwise in all other situations the non-additive effects were more important.

In the graphic analysis also overdominance was observed for grain yield, branch number and pod number in both the generations, whereas for seeds per pod and pod length in F_2 generation only. Genotype × environment interaction was less pronounced in F_1 and were found to be of high magnitude in F_2. The parents HUR-91, HUR-15 contributed dominant genes for yield, pod number, plant height and days to maturity.

The overall results of present investigation have brought out quite useful information with regard to nature of variability in the germplasm collected and the extent of divergence in the germplasm. Promising germplasm evaluated could be effectively used for future breeding programme. HUR-91 is observed to be very high combiner and should be used in future breeding programmes.

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TRIALLEL ANALYSIS FOR YIELD TRAITS IN SPRING & WINTER WHEAT DERIVATIVES

Arun Kumar Joshi Sup. : *Dr. G. S. Sharma*

The present investigation comprises triallel analysis (three-way cross analysis) in spring × winter wheat crosses to estimate the combining ability effects and variances, components of genetic variation and order effects in parental crosses for plant height, peduncle length, flag (-) leaf area, spike length, number of spikes/plant, number of grains/spike, grain yield/plant, 1000-grain weight and harvest index.

Six diverse (both genetically and geographically) varieties; two Indian dwarf, two Mexican dwarf and two Mexican spring × winter wheat derivatives were selected for the present study. Winter types do not come into heading under Varanasi conditions, therefore spring × winter derivatives were selected. Non-reciprocal F_1 crosses were attempted in diallel fashion in 1980-81. These F_1 hybrids were crossed to the parental lines to produce sixty three-way crosses at Wellington in summer of 1981. The final experiment consisted of sixty three-way crosses, was conducted in completely randomized block design with three replications at the Agricultural Research Farm, Banaras Hindu University, Varanasi in 1981-82 winter season. Each plot had single row accomodating 25 plants, spaced 10 cm within and 30 cm between the rows. Observations were recorded on 20 competitive plants per plot per replication for the nine characters.

Plot means were used for statistical analysis. Analysis of variance was performed by following Panse and Sukhatme (1967). The three-way cross (triallel cross) analysis was performed according to Ponnuswamy (1972).

The mean squares due to genotypes were highly significant for all the characters studied, indicating variability among different genotypes for these characters. The analysis of variance for three-way crosses (triallel analysis) showed that the general and two-line specific effects (both first and second kinds) as well as three-line specific effects were significant for all the nine characters.

In the present study, the magnitude of the additive genetic variance was higher than those of dominance variance for all the characters, except for grain yield and harvest index, indicating that these characters were under the control of additive genetic variance. However, for grain yield both additive and dominance components

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were important. As regards the digenic interactions, additive × dominance and dominance × dominance components were found to be important for controlling both yield and physiological traits.

General combining ability effects of first kind showed that WL 711 for number of spikes/plant, grain yield/plant, 1000-grain weight and harvest index; HUW 12 for tallness and flag leaf area; Nacozari 76 for dwarfness; Chiroca for number of grains/spike; PC 1031 for flag leaf area, number of spikes/plant, grain yield/plant and 1000-grain weight; Myna for peduncle length and spike length were found to be good general combiners. Therefore, these parents may be crossed as grand parents (parents of the F_1 cross in a three-way cross) for the improvement of various characters. Lines WL 711 for tallness, peduncle length, number of spikes/plant, grain yield/plant, 1000-grain weight and harvest index; HUW 12 for tallness, flag leaf are and number of spikes/plant; Nacozari 76 for dwarfness; Chiroca for plant height and number of grains/spike; PC 1031 for flag leaf area and 1000-grain weight; Myna for peduncle length and flag leaf area, were found to be good general combiners as immediate parent (as third parent in a three-way cross). It is interesting to note that some of the lines were observed to be good general combiners both as grand parents and parents as well. Thus, these parents may be crossed in any order in a three-way cross hybrid.

The *per se* performance of the parents was not positively related with their GCA effects in all the cases. It was not necessary that parents having high estimates of GCA effects would also give high estimates of SCA effects. In most of the cases, for almost all the characters, the crosses showing significant positive and high two-line specific effects of first kind combined either one good and the other poor general combiner or even both poor general combiners and the reverse was also observed. Apparently, the parents having low GCA effects had a relatively high magnitude of non-additive gene effects of thus resulted in high SCA effects when crossed.

Thus the choice of parents should be based on combining ability tests. The crosses showing high SCA effects involving one good and one poor general combiner, could produce desirable transgressive segregants if the additive genetic system present in the good combiner and the complementary epistatic effects in F_1 acted in the same direction to maximise the desirable plant attributes.

In general, positive and significant two-line specific effects of first and second kinds were observed by good × poor and poor × poor

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combiners. Distinct reciprocal differences were observed among the estimates of two-line specific effects of second kind for all the characters.

As regards three-line specific effects, positive and significant estimates were mainly in poor × poor × poor and good × poor × poor general combiners. Order effects in some triplets were quite distinct, while in few triplets order effects were very little. This clearly shows the importance of order in which the parents should be involved in crosses.

It was observed that the superiority of the triplet may be due to (i) either parent showing better general combining ability (general line effect), (ii) either cross showing better two-line specific effects, and (iii) the interaction between the three-lines used in making the triplet. The comparative study of one-line general effect with two-and three-line specific effects has clearly indicated that there is a great need to study not only three-line specific effects but also the order in which the parents should be crossed. Reciprocal effects have also indicated the importance of order effect of second kind (two-line specific effects). The prior knowledge of order effect will help in rationalizing the use of multiple crosses.

Three-way cross combinations involving high × medium × high yielding parents gave relatively higher yield performance as compared to other combinations.

One of the ways of increasing genetic yield potential of the varieties is by bringing diverse genes for yield into our spring wheats from winter wheats. Besides higher yield potential, the winter wheats are also known for drought tolerance, high tillering, greater winter hardiness and superior resistance to some diseases. On the other hand spring wheats have genes for better adaptability, chapati and bread making quallties and resistance to stem and leaf rusts.

In the present investigation two spring × winter derivatives, namely PC 1031 and Myna were selected. It is interesting to note that both these lines were found to be good general combiner for a number of yield contributing traits. Some two-line specific effects of first and second kinds were also positive and significant for different characters in the crosses involving PC 1031 or Myna. As regards three-line specific effects most of the crosses showing positive and significant effects involved one or both of the two spring × winter

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derivates. Similarly, majority of the three-way crosses showing higher yields had either PC 1031 or Myna or both. In general, higher means for all the characters were possessed by spring × winter wheat crosses.

The findings of the present investigation clearly indicate the possibilities of the improvement of spring wheats by introgressing desirable genes from winter types. Hence, it is suggested that large number of winter or winter × spring wheat derivatives from different winter wheat growing countries and CIMMYT, Mexico should be evaluated for their combining ability for desirable attributes and good combiners should be crossed with Indian spring wheats for the genetic improvement of spring wheats. Winter × spring wheat crossing blocks may be established at hills for attempting crosses of spring wheats with winter types. Spring × winter wheat derivatives may be utilized at plains where winter types do not flower.

INHERITANCE OF DWARFISM IN WHEAT AND EFFECT OF DIFFERENT DWARFING GENES ON GENETIC PARAMETERS AND PRODUCTIVITY

Eleswarapu Vani Divakara Sastry Sup. : *Dr. G. S. Sharma*

The present investigation comprises the studies on the inheritance pattern of the different dwarfing gene(s) or *Gai/Rht* factors present in a number of dwarf lines; allelic relationship among different genes/ identification of the *Gai/Rht* factors present in certain cultivars and the effect of ditferent *Gai/Rht* factors on yield, yield traits and genetic parameters. Combining ability variances and effects for plant height, yield and their components were also worked out. The possibilities for the exploitation of other dwarfing sources in the wheat improvement programme were also determined to widen the genetic base of the dwarness and other associated characters.

In the present study four different experiments were conducted. In the first experiment seven dwarfing sources, namely, Tanori 71, Tobari 66, Olesen, Norin, Tordo, D6899 and S 948Al were crossed with four tall Indian cultivars, namely, NP 846, NP 876, K 68 and Hybrid 65 during 1979-80 in a line × tester fashion to study the genetics of dwarfing genes present in these different lines. In 1980-81 crop season F_1s were raised to get the F_2 seeds. All the spikes of F_1 generation were bagged and fresh F_1s were also made. The 28 F_1s

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and 28 F_2s along with 11 parents were planted in Randomized Block Design with three replications at the Agricultural Experiment Station, Banaras Hindu University, Varanasi in 1981-82. Each plot of parents and F_1s was a single row and that of F_2s had nine rows each of 15 plants spaced 10 cm within and 25 cm between rows. Leaving the border plants, data were recorded on all the plants for plant height (cm).

Single plants data were used to estimate mean, range, variance and coefficient of variation of each cross in F_1s, F_2s and parents for height. Frequency distribution of the F_2 plants was also graphically represented. Inheritance pattern of dwarfness was observed on the basis of the F_1 and F_2 data.

In the second experiment, the same seven dwarfing sources involved in experiment No. 1 were crossed in all possible non-reciprocal combinations in 1979-80 to know the allelic relationship between different dwarfing genes and also to determine the combining ability for plant height, yield and their component characters. All F_1s were raised to get F_2 seed in 1980-81 crop season. All the F_1 plants were bagged to get F_2 seed and fresh F_1s were also attempted.

The 21 F_1s and 21 F_2s along with 7 parents were planted in compact Family Block Design with three replications at the Agricultural Experiment Station, Banaras Hiudu University, Varanasi in 1981-82. 21 F_1s plus 7 parents and 21 F_1s plus 7 parents were considered as different families. Each plot of parents and F_2s was a single row and that of F_2s had nine rows each of 15 plants spaced 10 cm within and 25 cm between rows.

Leaving the border plants data were recorded on all the plants for plant height, components of plant height (I, II, III and IV internodes starting from the base of the plant, peduncle length and spike length), number of grains per spike, grain yield per spike and grain yield per plant.

Single plant data were used to estimate mean, range, variance and coefficient of variation of each cross in F_1s, F_2s and parents for plant height. Frequency distribution of the F_2 plants was graphically represented for this trait.

Plot means for plant height, yield and their component characters were used to estimate combining ability analysis according to the procedure described by Griffing (1956).

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The heterotic pattern of the height due to the interaction of different dwarfing genes present in these seven dwarfing lines was also worked out.

In experiment No. 3, seven Indian and three Maxican released varieties, namely, HUW 12, HD 1949, HD 1982. HD 2204, UP 301, UP 262, UP 368, Sonalika, Nacozari 76 and Pavon 76 were crossed in a line × tester fashion with four testers of known dwarfing genes, namely, Tanori 71 *(Gai/Rht 1)*, Tobari 66 *(Gai/Rht 2)*, Torim 73 *(Gai/Rht 1 and 2)* and NP 852 *(Gai/Rht)* in 1979-80 to determine the different dwarfing gene(s) present in these wheat cultivars. The F_1 crosses were planted in 1980-81 and all the spikes were bagged to get F_2 selfed seed. Fresh F_1 crosses were also attempted.

Forty F_1s, forty F_2s along with fourteen parents were planted in Randomized Block Design with three replications in 1981-82. Each plot of parents and F_1s was a single row and that of F_2s had nine rows each of 15 plants spaced 10 cm within and 25 cm between rows.

Leaving the border plants, observations were recorded on all the plants for plant height.

Single plant data were used to estimate mean, range, variance and coefficient of variation of each cross in F_1s, F_2s and parents for plant height. Frequency distribution of the F_2 plants was graphically represented for plant height. The probable dwarfing genes were determined on the basis of above statistical parameters and the frequency distribution of the F_2 plants.

As regards, fourth experiment, three crosses namely, K 68 (*Gai/Rht*) × Tanori 71 *(Gai/Rht 1)*, K 68 (*Gai/Rht*) × Tobari 66 (*Gai/Rht 2*) and K 68 *(Gai/Rht)* × Tordo (*Gai/Rht 3)* were selected from the first experiment. Three separate trials were conducted in 1982-83. All the three trials consisted of the parents and random F_3 and F_4 lines from each of the three crosses. In all the trials the treatment plots were laid out randomly within replicates in a Randomized Block Design with two replications. Each treatment plot consisted of two rows of an experimental line accommodating 15 plants/row spaced 10 cm within and 25 cm between rows.

Only homozygous tall and homozygous dwarf lines were selected in F_3 and F_4 generations for recording of the data and the segregating lines were rejected in both the generations. Observations were recorded on 10 plants/plot for plant height, number of spikes/plant, number of grains/spike, grain yield/spike and grain yield/plant.

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The means for height, yield and yield traits within homozygous group were estimated in F_3 and F_4 populations separately.

The correlations between height, yield and yield traits were broken down into that due to the environment, background height genes and dwarfing genes (*Gai/Rht 1* or *Rht 2* or *Rht 3*). This was accomplished by extracting the relevant components of variation and covariation, and computing correlations from these.

Besides, to determine in true sense the effect of different dwarfing genes on yield and yield traits and plant height, isogenic lines are being developed involving 7 dwarfing sources into the genetic backgrounds of four Indian tall wheat cultivars, namely, NP 846, NP 876, K 68 and Hybrid 65 and also to thrash out the possibilities for the pratical exploitation of different dwarfing sources other than the Norin in the future wheat improvement programme to widen the genetic base for dwarfness and other associated characters.

The *Gai/Rht 1* gene of Norin 10 available in Tanori 71 showed no dominance in F_1 in the crosses with tall cultivars because F_1 was equal to the mid parental value, whereas *Gai/Rht 2* present in Tobari 66 showed partial recessiveness to partial dominance. The tall cultivars NP 876, K 68 and Hybrid 65 appear to have modifiers which modify the effect of major dwarfing gene(s).

The Tom Thumb gene *Gai/Rht 3* present in Tordo also showed no dominance in F_1 when it was crossed with the tall cultivars.

Norin containing both *Gai/Rht 1 and 2* genes exhibited no dominance to partial recessiveness in the crosses of tall varieties.

Other dwarf lines like O lesen, D 6899 and S 948A1 all showed partial recessiveness and a multimodel curve was observed in all the crosses. These dwarfing lines showed similar inheritance pattern.

All dwarfing genes such as *Gai/Rht 1*, *Gai/Rht 2*, *Gai/Rht 3* and *Gai/Rht 1+2* were under the genetic control of mainly additive gene effects or under predominance of additive gene effects.

Allelism was tested by observing the segregation in F_2 generation. Crosses involving different genes showed more segregation and the F_2 distribution surpassed the parental limits in F_2 and the reverse was also true for those crosses which possessed similar gene(s) for the character under study.

Norin 10 semi-dwarfing genes *Gai/Rht 1* and *Gai/Rht 2* are nonallelic to each other. *Gai/Rht 1* of Tanori 71 and *Gai/Rht 3* gene

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present in Tordo are likely to be alternative alleles or closely linked genes. The dwarfing genes present in Norin, Olesen, D 6899 and S 948Al seem to be the same. Thus D 6899 and S 948Al appear to have *Gai/Rht 1 and 2*. Besides *Gai/Rht 1 and 2*, Olesen should contain a third dwarfing gene which seems to be non-allelic to *Gai/Rht 1* and *Gai/Rht 2* genes.

The crosses of Tobari 66 (*Gai/Rht 2*) with HD 1982, HD 2204, UP 262, HUW 12, Sonalika and Pavon 76 showed the lowest range and variance in F_2 as compared to other testers and graphical representation showed long single peaked curve, indicating the presence of *Gai/Rht 2* gene in all these cultivars. Nacozari 76 showed the minimum F_2 range and variance and long single peaked curve with only Tanori 71 (*Gai/Rht 1*). It clearly shows the presence of *Gai/Rht 1* in Nacozari 76.

Similarly the minimum F_2 range and variance and single long peaked curves observed in the crosses of Torim 73 (*Gai/Rht 1 and 2*) with UP 301, UP 368 and HD 1949, whereas wide segregation and multimodel curves were obtained with other testers. It indicates the presence of both *Gai/Rht 1* and *Gai/Rht 2* genes in these triple dwarf cultivars.

The use of prior knowledge of the *Rht* genotype in the choice of the parents for hybridization was suggested to get the desired segregants of a particular height in the segregating generations.

Gai/Rht 1 and *Gai/Rht 3* increased significantly the number of spikes per plant as compared to *Gai/Rht* genotype, whereas *Gai/Rht 2* enhanced significantly number of grains/spike. The concept of tall dwarfs' was suggested to pick up the maximum high yielding alleles.

Besides Norin, the other dwarfing sources like Tordo, Olesen, D 6899 and S 948Al also have better prospects for their exploitation in the wheat breeding programme in near future.

The plant height and its component characters were under the influence of predominantly additive genetic variance, whereas yield and yield traits were controlled by both additive and non-additive components of variation. Simple selection was suggested for plant height in the early segregating generations, whereas for yield and yield traits modifications in the breeding methods were suggested.

Tanori 71 was observed good general combiner for peduncle length, number of grains/spike and grain yield. Tobari 66 was also good combiner for yield. Besides dwarfness, Tordo was found good

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general combiner for spike length and number of spikes/plant. Olesen was also good general combiner for number of spikes/plant.

The *per se* performance of the parents was positively associated with their GCA effects in almost all the cases. In most of the cases the crosses showing significant and positive and high SCA effects combined either one good and the other poor general combiner or even both poor general combiners and reverse was also true. Thus, the choice of the parents, particularly, for heterosis breeding should be based on combining ability tests.

In most of the cases, the best F_1s were not the cross combination which showed the maximum SCA effects. In majority of the cases, the best F_1 had involved one of the good general combiner/good performer as one of their parents and the other parent may be poor combiner/performer.

The crosses showing high SCA effects/F_1 performance involving one good and the other poor general combiner/performer, could produce desirable transgressive segregants if the additive genetic system present in the good combiner/performer and the complementary epistatic effects in F_1 acted in the same direction to maximise the desirable plant attributes.

INDUCTION, ISOLATION AND CHARACTERIZATION OF EUPLOIDS AND ANEUPLOIDS IN PEARL MILLET *(Pennisetum americanum* (L.) K. SCHUM)

Ramanujam Sai Kumar *Sup : Dr. U. P. Singh*

Pearl millet *(Pennisetum americanum* (L.) K. Schum) is an important food and feed crop of entire tropics and subtropics of the world. The cytomorphology on different sources of trisomics like translocation heterozygotes, desynapsis and triploids has been studied. A full set of primary trisomics and several tertiary and interchange trisomics have been isolated from translocation heterozygotes and triploids of pearl millet and their cytomorphological behaviour and transmission rate have been studied. The tetraploidy was induced in inbred H-8 of pearl millet and a study on cytomorphology, fertility and process of diploidization in induced tetraploids was carried out. The differnt aneuploids

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like double trisomics, tetra-trisomic, hypo-and hyper-triploids and tetraploids were isolated and characterized in additon to certain unusual chromosomal anomalies like fragmentation in translocation heterozygote and interchange trisomics; endopoliploidy, cytomixis and multiploidy were also studied.

One desynaptic plant was isolated in the selfed progeny of translocation heterozygotes of pearl millet. There was normal pairing at pachytene, but at diakinesis and MI a high frequency of univalents were present. The average number of bivalents per PMC was 0.23 and 0.21 at diakinesis and MI, respectively. At AI, a high frequency of PMC's (approx. 83%) showed unequal chromosome distribution; some PMC's (4.2%) showed 13:1 separation. Lagging chromosomes were observed in 37.5% PMC's; the number of laggards per PMC ranged from 1 to 4. A high frequency of PMC's showed micronuclei at TI and TII. The plant showed a very high (94%) pollen sterility, but ovule fertility was normal.

To understand the mechanism of variation in chromosome number in the progeny of triploids, the cytological and other aspects were investigated. Due to autotriploid nature of pearl millet, the association of chromosomes at MI varied considerably, which in turn had profound influence on AI separation. The separation pattern at anaphase I with 10-11 chromosomes was highest (46%) and lowest in 13-1-7 separation (1%). Pollen sterility of triploids varied from 90-96 per cent. The progeny ranged from open pollinated seeds were, therefore, the result of pollination from diploid plants. From the freqnency of observed and expected progeny, the gameta selection was inferred. Though egg cells with 10 to 13 chromosomes are functional but most of them were eliminated due to influence of selective fertilization mechanism.

Primary trisomics were isolated from triploid plants. These primary simple trisomic plants were distinguishable from the diploids by their relatively poor vigour, reduced plant height, narrow and grassy leaves and late flowering. They were also distinguishable from one another and were classified into seven morphological groups : 'Tiny', Dark Green', 'Lax', 'Slender', 'Spindle', 'Broad', 'Pseudonormal'. All the primary trisomics showed $1^{III} + 6^{II}$ or $7^{II} + 1^{I}$ at diakinesis and metaphase I. The frequency of trivalents was reduced at metaphase I. The trivalents were visible in chain, V-,frying-pan, Y-, J- and L-shaped structures.

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Chain trivalents were most frequent and V-shaped the least. Frequency of chain trivalents increased at metaphase while that of others decreased. At anaphase I 8 vs. 7 disjunction of chromosomes was most frequent, though laggards and their precocious division were also observed in a few cells.

Transmission rates of the extra chromosomes in seven primary trisomics of pearl millet were estimated by examining the progeny of selfed trisomics and the progeny when the trisomics were crossed to disomics. When the trisomics were selfed, 'dark green' and 'tiny' had the highest transmission rate (23.8% and 23.2%, respectively) and pseudonormal the lowest (13.8%). When the trisomics were used as females in crosses with disomics, both (tiny and dark green) again had the highest transmission rate and pseudonormal the lowest (11.9%); when the trisomics were used as males in crosses to disomics, transmission rate was zero except in spindle at low frequency (2.0%). Variation in transmission rate was observed from plant to plant and season to season for the same trisomic type. Study of the transmission rate of the extra chromosome indicated that the following factors probably were contributing to the lower rate of transmission ; small or light seeds tended to have a higher proportion of trisomics than heavier seeds; lighter seeds had a lower percentage of germination; the extra chromosome was rarely eliminated during meiosis; trisomic plants were less vigorous than disomics and tended to attain reduced plant height. Trivalent frequency and transmission rate were highly correlated. But mostly longer extra chromosome of the set formed the trivalents in a higher frequency. Hence, the trisomics (tiny and dark green) with longer extra chromosome were highly sterile but their transmission rate was maximum.

Nineteen tertiary trisomics were isolated from some translocation heterozygotes and interchange trisomic of pearl millet. Cytological analysis of these trisomics indicates that chromosome association of trivalents, univalents and pentavalents were frequent in all the trisomics. But their ratio varied from one trisomic to the next. Other associations were relatively infrequent. The relative frequencies of six pentavalent configurations observed in different trisomics were studied and their probable association with mode of fertility and transmission rates have been discussed. In addition one tertiary trisomic with translocation heterozygote was isolated in the progeny of an interchange trisomic.

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Twenty five interchange trisomics were isolated from an interchange trisomic and translocation heterozygotes of pearl millet. Cytological analysis of these trisomics indicates that chromosome associations of trivalents and univalents were frequent with comparatively less frequency of O_4 and pentavalents in all the trisomics. Other associations were relatively infrequent. Transmission rate and breeding behaviour of all the interchange trisomics were studied for three seasons and it was found that transmission of primary trisomics was more than that of other trisomics.

Further, primary trisomic interchange heterozygote and complex interchange trisomic have also been studied cytologically.

Tetraploidy was induced in pearl millet following seed and seedling treatment with different concentrations of colchicine at different durations. The 0.4% concentration of aqueous solution of colchicine proved more effective and seedling treatment was preferred over the seed treatment. Thus, a study on induction of colchiploidy would be useful for those who wish to induce ploidy in pearl millet. Tetraploids, thus, produced were advanced to C_3 generation and their cytomorphology, breeding behaviour and process of diploidization were studied.

The C_0 plants were differentiated strikingly in some characters from the corresponding diploids. A great range of variation was noticed for plant height, number of tillers, leaf length, earhead length and width from C_0 to C_3 generations of tetraploids. Besides plant height and number of tillers, other characters of tetraploid, showed superiority over those of diploid in C_0 generation. In general, the plants had broad, thick and dark green leaves with vigorous florets, pistil and anthers. Seeds of tetraploid were bold with a thousand grain weight of 9.470 gm, in contrast to 6.252 gm of diploid from which they arose.

The average number of quadrivalents/cell in C_0 generation was 0.90 whereas the number of bivalents/cell was 12.22. The number of quadrivalents/cell ranged between 0 to 7 at diakinesis. The number of univalents were more than trivalents. At MI, the frequency of quadrivalents/cell decreased with a concomitant increase in the frequency of univalents and bivalents. The number of bivalents and quadrivalents/cell was 12.22 and 0.90, respectively in C_0 generation and the corresponding figures for bivalents and quadrivalents were 13.52 and 0.23 in C_3 generation. At AI, certain chromosome distri-

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butions like 14:14 was maximum followed by 15:13, 16:12 and 17:11 in different generations of tetraploids.

There was a gradual decline in number of univalents and multivalents with a concomitant increase in number of bivalents/cell from C_0 through C_3 generation. The disjunctional index of C_0 tetraploids was nearly 47.1%, but its value in C_3 generation was more than 67%.

Cytological 'diploidization' in succeeding generations i. e., a gradual shift from multivalents to bivalent type of association was observed in autotetraploids. In C_0 generation, nearly 43.3% of total PMC's studied carried 14 bivalents whereas in C_3 generation, nearly 87.1% of PMC's were associated with 14 bivalents. Some probable hypotheses have been postulated to explain the 'preferential pairing' observed in the evolved tetraploids of pearl millet

Due to breakdown of tetraploids, nearly 77% plants were found to be diploids in C_1 generation whereas in C_2 generation, the reversal was almost completely restricted barring few aneuploids (6 chromosome variants with 27-, 29- and 30 chromosomes) observed in the tetraploid progeny.

The double trisomics were distinguishable from their diploid sibs by their reduced plant height, leaf length, width, earhead length and width. But number of tillers in the double trisomics derived from the first triploid were significantly higher in comparison to those isolated from the second triploid. The cytological investigation reveals the involvement of both longer extra chromosomes in first double trisomic whereas in second trisomic at least one extra chromosome was the shorter one.

A plant was reported to possess 17-chromosomes in the progeny (comprising 99 plants) of an open pollinated triploid pearl millet. The frequent occurrence of PMC's (40%) with a chain or ring of 4 chromosomes with $1^{III} + 5^{II}$ at diakinesis and MI may be attributed to its tetra-trisomic nature. Simultaneously a complete absence of PMC's with 2^{III} but regular occurrence of one quadrivalent in majority of cells (55%) excludes the possibility of its becoming as a triple trisomic. The average frequency of univalents, bivalents, trivalents and quadrivalent/cell was 3.45, 4.4, 0.85 and 0.55, respectively.

A dwarf plant with 19 chromosomes (hypotriploid) was isolated in the progeny of tripoid pearl millet. Barring tiller number and ear

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girth, other morphological attributes of this stock were highly reduced as compard to those of normal disomic sibs. In addition the earhead of this plant resembled with that of sorghum. The average number of univalent, bivalent, trivalent and quadrivalent per cell at diakinesis were 2.00, 3.47, 2.87 and 0.37, respectively. Similarly, an average association of $7.05^{I} + 3.87^{II} + 1.11^{III}$ and 0.22^{IV}/cell was noted at metaphase I. The presence of $3^{III} + 1^{IV}$ in addition to 3^{II} in majority of cells could be explained on the assumption that the plant is tetrasomic for one chromosome and trisomic for three different chromosomes of the complement. Thus, this hypotriploid may also be referred as tetratriple trisomic which has been reported for the first time in pearl millet.

A hypertriploid (2n = 22) was detected in the progeny of a partially desynaptic trisomic (2n = 15) plant of pearl millet. The hypertriploid was supposed to have been derived by fertilization of unreduced female gamete (2n = 15) of trisomic with that of normal pollen. The hypertriploid differed in morphology from its maternal-sibs, but showed comparable morphology with those of triploids. The microsporocytes showed a mean chromosome association of $2.34^{I} + 2.96^{II} + 4.43^{III} + 0.1^{IV}$ at metaphase I with a mean chiasmata number of 13.40 per cell. The twenty types of observed chromosome configurations could be explained by assuming that plant was trisomic for six chromosomes and tetrasomic for one chromosome. Four chromosome associations such as $5^{II} + 4^{III}$, $1^{I} + 6^{II} + 3^{III}$, $2^{I} + 7^{II} + 2^{III}$ and $8^{II} + 2^{III}$ suggested the presence of displaced duplications or small interchanges within the genome of pearl millet. The tetrasomic chromosome formed mostly a quadrivalent which often broke down to form 2^{II} or $1^{I} + 1^{III}$ and rarely $2^{I} + 1^{II}$ or 4 univalents. Most of the univalents arose from the trisomic chromosomes. Abnormal distribution of chromosomes at AI resulted in the formation of diads and tetrads with unequal chromosome numbers. The hypertriploid could be distinguished from trisomic maternal sibs by most (if not all) visible morphological characters such as plant height, tillering ability, leaf width, earhead length and ovule sterility, but set some seeds upon open pollination.

Aneuploids with 27-, 29- and 30-chromosomes were isolated in the progenies of induced tetraploids of pearl millet in a lower frequency in C_2 generation. These aneuploids were apparently recovered through

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female transmission, which varied for aneuploid gametes with different chromosome numbers. Aneuploids could be distinguished from eu-tetraploids on morphological basis. Cytological study showed that 27-chromosomes variant was characterized by a high frequency of univalents and their precocious splitting at AI in addition to rare presence of trivalents and quadrivalents/cell. But, bivalents were highly frequent in both hypertetraploids. Thus, a high frequency of bivalents is suggestive of "preferential pairing". Moreover, the induced bivalentization noted in both eu-and aneuploids of advanced generation tetraploids of pearl millet may be accounted to high selection pressure.

A dwarf plant deficient for a chromosome fragment was isolated in the progeny of an irradiated complex interchange heterozygote. Most of the PMC's studied at diakinesis were associated with $6^{II}+2^{I}$ and due to some pairing affinity both univalents were oftenly found lying closer to each other. Morphologically one of the univalents was bigger in size and formed either U- or rod- or cresent shape of structure at diakinesis while its partner smaller univalent being associated with certain deficiency mostly formed a ring shaped structure. The centromeric activity of deficient chromosome was maintained throughout the meiosis.

A plant in the progeny of translocation heterozygote was found to have 2n with one chromosome fragment attached with nucleolus observed in most of the PMC's of this stock. The PMC's with the fragment showed a heteromorphic bivalent or trivalent at diakinesis (1.7 and 12.1%) and metaphase I (3.0 and 10.0%). The movement of fragment to one of the poles in 71.4% of PMC's indicates that this is a centric fragment.

In the progeny of an interchange trisomic, a plant was found to interchange trisomic associated with an extra fragment. About 53.8 and 47.4 percent of PMC's exhibited $5^{II}+1^{V}$ with a fragment and 26.9 and 42.1 percent of PMC's showed $5^{II}+1^{O}\ 4+1^{I}$ with a fragment at diakinesis and metaphase I, respectively. The fragment was found to be associated with a bivalent forming heteromorphic^{III} at diakinesis (7.7%PMC's) and metaphase I (53%PMC's). The corresponding frequency of heteromorphic bivalent was 11.5 and 5.3% of PMC's at diakinesis and metaphase I, respectively. At anaphase I, the fragment moved to either pole in 85.7 per cent of PMC's and the centromeric activity of fragment was maintained during meiosis.

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In the selfed progeny of a translocation heterozygote of pearl millet, one plant exhibited polyploid PMC's and cytomixis. About 47% of the PMC's had chromosome numbers ranging from 42 to 322. The polyploid PMC's showed bivalents and univalents but no definitive multivalents. At anaphase I, unequal separation and laggards were observed in considerable frequencies. Micronuclei were oftenly observed at TI and TII. Cytomixis was confined to the polyploid PMC's and involved 2, 3 or 4 cells.

Certain PMC's of a multiploid isolated from an interchange trisomic had variable number of chromosomes in the range of 15 to 120/cell approximately. In addition to $6^{II} + 1^{III}$ and $7^{II} + 1^{I}$ /cell, different chromosome associations like 60^{II}, $45^{II}\ 4^{II} + 52^{I}$, $3^{III} + 18^{II} + 75^{I}$, $20^{II} + 5^{I}$, $5^{III} + 10^{II} + 85^{I}$ and $22^{II} + 16^{I}$ were found in 7.6%, 5.7%, 2.9%, 2.9%, 2.9%, 1.9%, and 1.9% of PMC's, respectively, in the descending order of magnitude. At anaphase I certain PMC's (5.6, 2.2 and 11.1 per cent) showed 23:22, 65:55 and 60:60 disjunction, respectively.

The predominance of bivalents and a complete lack of multivalent association observed in many multiploid PMC's of this stock suggest that probably certain genetic system causing bivalentization has restricted the formation of multivalents.

GENETICS OF PROTEIN AND YIELD COMPONENTS IN CHICKPEA (*Cicer arietinum* L.)

Parshotam Singh *Sup. Dr. B. D. Singh*

The present investigation was undertaken to determine variability for protein, tryptophan, methionine and protein fractions; their association with yield and protein content; and to characterise various genetic parameters for these characters together with yield traits through a 9×9 diallel analysis of chickpea (*Cicer arietinum* L.). Genetic studies on influence of the maternal genotype on protein, tryptophan and methionine contents, and on electrophoretic profiles of seed protein of the 9 parents were also carried out.

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Nine diverse chickpea lines, namely, T–3, 5905, T–1–A, NEC–969, Annigeri–1, P–636, RPSP–4, H–208 and P–5482 were selected from 65 chickpea lines on the basis of protein content, and were crossed according to a diallel mating design, without reciprocals. Five parents were ordered into a separate diallel including reciprocals to study maternal effects. In both the cases, F_1 and F_2 generations were produced. Parents and the progenies of the 9×9 dialiel were planted in R. B. D. with three replicates, while those of the 5×5 diallel were grown in R. B. D. with two replicates. Observations were recorded on plant height, primary branches, secondary branches, seeds/pod, pods/plant, 100-seed weight, yield/plant and protein content in F_1 and F_2 generations, and for tryptophan and methionine contents and various protein fractions, *viz.*, albumins, globulin-1, globulin-2, total globulins, prolamins and glutelins, in F_1 (for protein characters seed from F_1 plants, i.e., F_2 seed, was used).

There was statistically significant reciprocal difference in protein, tryptophan and methionine contents of F_1 seeds, but no effect in the F_2 seeds. This reveals a strong effect of the maternal genotypes for these traits. Further, the contents of tryptophan and methionine were statistically significantly lower than those of the female parent even when it was inferior indicating negative heterosis.

Electrophoretic protein profiles of the 9 parents did not differ much inspite of the variability for protein content, indicating this trait to be highly stable and conservative. B zone did not show any variation, while A and C zones showed some variation in the minor bands.

Globulin-1 and globulin-2 formed the major fraction of seed proteins; together they account for nearly 70 per cent of the total proteins. The next major group of seed proteins was glutelins followed by albumins. Prolamins formed a negligible fraction of total seed protein in chickpea.

The progenies of the 9×9 diallel differed significantly for all the characters, except prolamins, suggesting significant genetic diversity among the parents and progenies. The 't^a' estimates were nonsignificant for all the characters, except primary branches, globulin–1, globulin–2 (all in F_1), secondary branches and pods/plant (in F_1 and F_2) indicating the uniformity of Vr, Wr values for most of the characters. The regression coefficient 'b' significantly deviated from

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unity in case of plant height, tryptophan content, globulin-1, globulin-2 (all in F_1), primary branches, secondary branches, seeds/pod and pods/plant (all in F_1 and F_2 both). This indicated presence of epistasis and/or correlated gene distribution among parents for these characters.

Graphic analysis revealed partial dominance for all the yield characters and protein content, in both the generations, except plant height and primary branches in F_1, which exhibited overdominance. The Vr, Wr graphs showed overdominance for all the protein quality characters, except for globulin-2, where partial dominance was revealed.

The components of genetic variation revealed significance of additive component (D) for plant height (F_2), seeds/pod (F_1, F_2), pods/plant (F_2), 100-seed weight, yield/plant, protein content (all in F_1, F_2), tryptophan, total globulins and glutelins (all in F_1). The dominance component, H_1 and H_2, were significant for all yield and protein quality characters, except for secondary branches (H_1 in F_1). The environmental component (E) was significant for most of the character indicating the influence of environment on the populations. The average degree of dominance, $(H_1/D)^{\frac{1}{2}}$, was more than one for all the yield characters and protein quality characters, except 100-seed weight, yield/plant and protein content, in both the generations. The ratio $H_2/4H_1$ suggested symmetrical distribution of positive and negative alleles among the parents, and K_D/K_R was higher than one for most of the characters indicating predominance of dominant alleles among the parents. The ratio h^2/H_2 indicated 1 to 3 genes or groups of genes controlling these characters. Heritability (narrow sense) was high for pods/plant (F_1), 100-seed weight, yield/plant and protein content (all in F_1, F_2); it was moderate for plant height (F_2), primary branches (F_1), secondary branches (F_1, F_2), seeds/pod (F_1, F_2), pods/plant (F_2) and tryptophan (F_1); and was low for the remaining characters.

In this study, two critical assumptions of diallel, i. e., absence of epistasis and independent distribution of genes among the parents, are likely not to have been fulfilled. Therefore, graphic and component analyses of the data have been done with the view to indicate the complexity of the genetic control of the quantitative traits and to impress the necessity for using a design, such as generation mean analysis, that would take into account the interallelic interactions

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revealed by the graphic analysis. The results obtained from graphic and component analysis, are therefore, tentative.

The combining ability analysis revealed significant gca and sca variances for yield and yield traits in both the generations, except for plant height (sca in F_1), and primary branches (sca in F_1, F_2 both). The proportion 26^2 g/6^2s (Additive/Dominance) was more than one for plant height (F_2), primary branches (F_1, F_2), seeds/pod (F_2), 100-seed weight, yield/plant and protein content (F_1, F_2), indicating a preponderance of the additive component. In case of the remaining characters, including protein quality characters, the nonadditive component played a predominant role. Thus, the graphic, component and combining ability analyses were in accordance for 100-seed weight, yield/plant, protein content, and all the protein quality characters, except globulin-2.

The gca effects of the parents showed positive association with *per se* performance. Parents T–3 and Annigeri–1 were the best general combiners for the maximum number of characters, *viz.*, 100-seed weight, yield/plant, tryptophan and methionine contents. P–636 and RPSP–4 were the best parents for pods/plant and T-1-A and 5905 for protein content. The best cross combinations, in F_1, F_2 or both, which exhibited high sca, involoved one good and one poor combiner or both poor combiners for most of the characters. The cross combination that showed high sca effects did not, necessarily, exhibit the best *per se* performance. T–3 × T–1–A was the best cross combination for yield/plant and T–3 x Annigeri–1 for protein content.

Correlation coefficients were estimated separately for yield and yield components including protein (parent+F_1, and parent+F_2 populations), and for protein content and protein quality characters (parent + F_1 population). Grain yield showed significant position correlation with plant height, secondary branches, pods/plant and 100-seed weight total globulins, prolamins and glutelins, whereas its association with protein content was negative. Protein content showed significant negative association with plant height, seeds pod, 100 seed weight, methionine content albumins and prolamins. Protein content showed significant positive association with secondary branches, globulin-1, globulin-2, total globulins and glutelins.

Path analysis revealed that plant height, seeds/pod, pods/plant and 100-seed weight were the direct positive contributors of yield in both the generations. Among the protein quality characters, tryptophean

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content, albumins, globulin-1, globulin-2, prolamins and glutelins showed positive direct effect on yield, but correlation with yield was significant only for prolamins which formed a nonsignificant fraction of seed proteins. The direct and indirect effects of yield components on protein content were not much important.

Tryptophan content, albumins, globulin–2, total globulins and prolamins were the direct positive contributors to total protein, of which only globulin–2 and total globulins were important because they had positive correlation with protein content. Total globulins appear to be the most important fraction for which selection may be done while selecting for higher protein containing genotypes, followed by globulin–2, globulin–1 and glutelins.

GENETIC VARIABILITY FOR ALKALINITY/SALINITY RESISTANCE IN WHEAT

Kailash Narayan Singh *Sup. Dr. R. S. Rana*

This investigation, comprising of four inter-related studies, was undertaken primarily with a view to assessing and analysing the magnitude and nature of variability for salt-resistance in some genetically diverse wheat varieties. A pilot study was first carried out in polythene-lined wooden trays comparing response of 33 wheat genotypes to soil salinity and alkalinity (sodicity) based on seed germination and seedling emergence rate criteria. One barley and one triticale varieties were also included as checks. Eighteen selected genotypes were then planted in specially-designed stress-plots for a more critical study of salinity and alkalinity effects on grain yield and related characters. Stability analysis of their grain yield performance under six environments was also done, soil salinity and alkalinity ranging from ECe 0.9 to 10.1 dS/m and pH_s 7.8 to 9.3, respectively.

In addition, comparisons were also made with respect to chemical composition of plants growing under different edaphic environments, both favourable as well as less favourable, so as to understand relationships, if any, between mineral content of plants at tillering phase and important plant attributes of vegetative and reproductive phases. Finally, six varieties, representing different levels of observed

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salt-resistance, were used in a diallel set of crosses for assessment of their combining ability for the desired traits and also for analysis of genetic components of variation. Salient features of the results obtained from these studies are summarised as follows :

1. Both soil salinity and alkalinity led to considerable delay in seedling emergence basides reducing the seed germination. Based on the edaphic stress effects upon germination and the rate of emergence, it was possible to group the forty genotypes under study into three groups, namely, resistant, moderately resistant and sensitive. While wheat varieties Kharchia 65, HP 833 and HD 1982 together with the barley check DL 70 were prominent among the resistant group, wheat variety HD 2009 was judged to represent the moderately resistant response. The sensitive group comprised largely of tetraploid durum varieties such as HD 4530, JNK-4W-184 and LSW-34.

2. Chemical analysis of plants at the tillering phase for Na, K, Ca and Mg contents revealed that the presence of excessive quantities of salts, both neutral as well as alkali types, affected Na content more pronouncedly than that of other minerals. This observed increase in Na content was found to be more striking in case of soil alkalinity (sodicity) than that of salinity. Varietal differences in this respect were, however, conspicuous; the resistant group on the whole registering a lower and slower increase in marked contrast to other groups.

3. Correlation analysis among plant mineral contents and grain yield contributing traits revealed a significant negative relationship between Na content and grain yield in contrast to a significant positive association between K content and the grain yield indicating that K/Na index of young plants could be used to predict the stress-response of adult plants as measured by the reduction in grain yield.

4. Joint analysis of stability parameters brought out significant differences among the genotypes and also the environments showing that a major portion of variation with changes in environments was accounted for by a linear function of additive environmental effects in case of the eight characters studied. Distinctly superior stability of the wheat variety

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HD 1982 with respect to grain yield was found to be a reflection of the stability of its component traits contributing to the overall yield performance.

5. Analysis of variance for ten characters showed presence of considerable variability in this regard, among the parental genotypes as well as crosses, indicating that the choice of materials for the genetic studies was appropriate. Environments were also found to be distinct as reflected in the population mean values.

6. With some variation notwithstanding, low to moderate estimates of heritability were observed for spike length, spikelet number per spike, number of grains per spike and grain weight.

7. Mean squares due to gca as well as sca were found to be significant for all the characters and under all the edaphic environments indicating thereby the importance of both additive and non-additive types of gene effects in controlling these traits. The ratio sca/gca as well as generation mean analysis showed the preponderance of non-additive effects for grain yield and number of ear-bearing tillers, while additive effects were predominant in case of plant height and days to ear-emergence.

8. Estimates of gca showed that none of the parents was good general combiner for grain yield under both favourable and edaphic stress environments. Good general combiner for individual environments were, however, noted such as HD 2009 and WL 711 for favourable soil, Kharchia 65 and WH 157 for alkali soil and HD 1982 for saline soil. In addition, the following varieties were considered desirable. Kharchia 65 and WH 157 for tiller number under alkali soil; WL 711 for number of grains per spike and grain weight under all the three environments; and HD 1553 for grain weight under favourable and saline soils.

9. Based on sca effects, it was found that the cross HD 2009 × Kharchia 65 was desirable for grain yield under all the edaphic environments under study. This cross was also found suitable for tiller number per plant, number of spikelets per spike and grain weight in both saline and alkali soils.

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The cross Kharchia 65×WL 711 proved superior for grain number per spike under favourable as well as unfavourable soil environments.

These findings have been discussed suggesting a breeding strategy for combining superior resistance to soil salinity and alkalinity with high yield potential in wheat. In view of the observed distinct intervarietal differences regarding resistance to saline and alkali soil conditions, it has been concluded that breeding varieties suited to salt-affected soils appear to be a promising proposition in the case of hexaploid wheats, i. e., bread wheats. There is, however, an urgent need to develop simple, efficient and non-destructive selection criteria for this purpose. It has also been suggested that planned and more vigorous efforts should be directed towards systematic collection and critical evaluation of indigenous wheat cultivars from distinct salt-affected situations so as to provide a wider range of genetic variability for both basic studies as well as breeding programmes.

GENETICS OF YIELD AND POWDERY MILDEW RESISTANCE IN PEAS *(Pisum sativum* L.)

Mahendra Narain Singh — *Sup. : Dr. R. B. Singh*

The present investigation was undertaken to elucidate genetic architecture of a set of diverse cultivars of pea for ten quantitative characters and reaction to powdery mildew incidence. Various genetic parameters, such as, components of genetic variance, combining ability variances and effects, heritability, heterosis and inbreeding depression, gene effects (including interaction effects), character associations and path co-efficients were estimated by using variance, co-variance, diallel, scaling test and generations mean analyses.

Non-reciprocal diallel crosses comprising twelve diverse and *elite* cultivars of pea, namely, T163, L116, B5064 (tall); GC141, PI280064, Bonneville, PG3, Sel–2, A474-288 (medium tall); GC322, Early December and EC33866 (dwarf), were used in the present study. A474-288 was resistant to powdery mildew while the others were susceptible.

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The 66 diallel F_1 crosses along with their parents were grown in randomised block design with three replications during rabi, 1977-78. The final experiment consisting of 66 each of F_1s, F_2s and 21 each of B_1s and B_2s along with their parents were sown in compact family block design replicated three times at the Agriculture Research Farm, Banaras Hindu University, during rabi, 1978-79. The families and progenies within families were randomised in each replication. Observations were recorded on ten plants from each of parents, F_1s and backcrosses and on fifty plants from each of F_2s for ten characters, namely, plant height, number of primary branches, number of secondary branches, pods per plant, pod length, seeds per pod, 25-seed weight, yield per plant, days to flowering and days to maturity. Plot means of the different characters were used for statistical analyses.

The additive component ($\hat{D}$) was significant for all the traits in both the generations except for pods/plant and yield/plant (F_1). The non-additive component ($\hat{H}_1$ and $\hat{H}_2$) were also significant except $\hat{H}_2$ for number of secondary branches and pod length. The $\hat{h}^2$ was mostly positively significant for all the traits except for 25-seed weight and number of branches (F_1) and negatively significant for pod length and seeds per pod (F_2). $(H_1/D)^{\frac{1}{2}}$ indicated that number of secondary branches, pod length seeds per pod, 25-seed weight, days to flowering and days to maturity had higher magnitude of additive genetic component whereas reverse was the case for plant height, number of primary branches, pods per plant and seed yield per plant. The graphic analysis also supported the above conclusion and further revealed the presence of non-allelic interaction for seeds per pod, seed yield per plant, plant height, number of secondary branches, pods per plant, 25-seed weight and days to flowering (F_1).

Parents L116, GC322, Sel-2, PG3, PI280064 and T163 had higher proportion of dominant alleles, while early December, EC33866 and GC141 carried more of recessive genes for majority of traits studied.

Asymmetrical gene distribution was observed in majority of the cases. Dominant and recessive alleles were in equal proportion in parents for number of secondary branches and 25-seed weight in F_1.

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The number of groups of genes showing dominance was low in most of the characters.

Analysis of standardized deviation graph indicated that high value of plant height, days to flowering and days to maturity were under the greater control of positive dominant genes, whereas there was almost an equal concentration of positive and negative genes in the parents for other traits. Significantly positive 'F' value for days to flowering and maturity along with number of secondary branches, pods per plant, 25-seed weight and seed yield per plant (F_2), further confirmed the importance of dominant alleles. Heritability was high for days to flowering and maturity, pod length, seeds per pod and 25-seed weight while very low for seed yield per plant and pods per plant (F_1).

The GCA and SCA variances were highly significant for all the traits studied. The variance due to GCA x year (environment) and SCA x environment were also highly significant for all the traits except the GCA x environment variance, for pod length. As revealed by σ^2A/σ^2D ratios, the magnitude of non-additive component was higher than additive component for most of the traits except for pod length, seeds per pod and days to maturity (F_2) where, higher magnitude of additive component was indicated. The combining ability analysis pooled over two years also showed similar results, by and large.

The GCA effects were usually positively associated with *per se* performance of the parents. T163 and Sel-2 for seed yield; Sel-2, T163, PG3 and Bonneville for 25-seed weight; GC141, PI280064, GC322, Early December and EC33866 for seeds per pod; Bonneville, GC141, PG3, Early December and GC322 for pod length and T163, L116, and 5064 for plant height, were the most promising general combiners. The top general combiners for early flowering were Early December, EC33866 and A474-288, and for early maturity were EC33866, Early December and GC322. L116, 5064 and T163 for pods per plant and T163 and PI280064 for primary branches, proved promising general combiners.

The estimates of SCA effects, in general were lower in F_2. Most of the crosses showing significant positive SCA effects involved one good and one poor or even negative general combiners. Relatively higher estimates of SCA effects were usually recorded in those crosses which involved parents of distant origin, particularly of different height groups.

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Analysis of generations mean further suggested that for plant height, pods per plant, seed yield per plant, days to maturity and number of primary and secondary branches, the relative contribution of dominance gene effect was higher than additive gene effects while for seeds per pod, and days to flowering additive gene effects were predominant. Duplicate type of epistasis was prevalent than complementary type for all the traits except for 25-seed weight. Additive × additive appear to contribute maximum though dominant × dominant were mostly negative but comparatively higher than other two types of gene interactions.

The various analyses revealed that both additive and non-additive genetic variances are important in controlling yield and yield contributing traits in pea. The relative magnitude of two component varied from character to character, though additive genetic variance was higher than non-additive genetic variance for most of the yield components but for seed yield per plant where an excess of non-additive gene effects were indicated.

Studies on heterosis over better parent and standard variety (economic heterosis) exhibited high promise for crosses 5064 × Early December and GC141 × 5064 over their better parents and T163 × Sel-2 and T163 × Bonneville over standatd variety i. e. T163. In general, higher heterotic effects were associated with higher inbreeding depression. Diversity of the parents was associated with the degree of heterosis of the F_1s, the diverser the parents, the greater was the heterosis.

The estimates of genotypic correlation coefficient were generally higher than the corresponding estimates of phenotypic correlation coefficient. Seed yield was significantly positively associated with 25-seed weight and pods per plant in all the populations. Plant height, number of primary branches, number of secondary branches, days to flowering and days to maturity, pod length and seeds per pod were also positively and significantly associated with seed yield in one or the other population. 25-seed weight had negative association with seeds per pod and pods per plant (F_2), while seeds per pod and 25-seed weight were positively and significantly associated with pod length. Number of seeds per pod was usually negatively associated with 25-seed weight. Days to flowering, days to maturity, plant and number of branches had significantly positive association among themselves.

Path coefficient analysis suggested that 25-seed weight, seeds per pod and number of secondary branches had high direct effect

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on seed yield. However, plant height and pod lengh in the parents and F_1s and pods per plant in the F_2s also had pronounced effect on seed yield. Days to flowering and days to maturity had negligibe effect on yield in the F_2s while their effects were strongly negative in the parents and F_1s (except maturity in the parents).

Powdery mildew resistance of the parent A474–288 was controlled by a single pair of recessive genes. The resistant segregants in the F_2s and test crosses showed similar reaction to the disease as the resistant parent.

Based on the above findings, following suggestions are made to plan efficient and effective breeding methods for improving yield of pea—

(1) Diverse parents preferably of different height groups should be selected on the basis of their *per se* performance as well as combining ability;

(2) In crosses comprising high mean parents with high fixable gene effects, follow pedigree or modified pedigree method of selection;

(3) In those crosses, such as T163 × Bv and T163 × Sel-2, where both additive and non-additive gene effects were significant, a population improvement approach would be most effective;

(4) Selection should be practised on the basis of respective weight of different components such as 25-seed weight, seeds per pod and pod per plant for avoiding genetic slippage;

(5) Heterosis breeding for increased yield could be profiteering especially in home gardens, provided economical means of production of desired quantity of F_1 seeds are available; and,

(6) Pea varieties resistant to powdery mildew could be evolved by crossing the high yielding but otherwise susceptible varieties with resistant sources. The segregating population could be handled either through pedigree method or backcross method to select high yielding and resistant varieties.

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GENETIC VARIABILITY-NATURAL AND INDUCED AND ADAPTABILITY IN JAPANESE MINT (*Mentha arvensis Linn. subsp, haplocalyx Briquet var. piperascens Holmes)*

Om Prakash Singh *Sup. : Dr. R. M. Singh*

A set of 30 clones of *M. arvensis* were subjected to multivariate analysis, G×E interaction and character-association studies for some economic traits in this investigation. In addition, one clone was also irradiated with gamma-rays to examine the nature and magnitude of induced variability created therein.

All the test-clones were grown in replicated trials at two locations (Lucknow and Pantnagar) for two years (1979 and 1980) under two fertility levels (High and Low) in each case. The irradiated material was, however, raised only at Lucknow under high fertility condition.

Metric data were recorded on plant height, number of branches, leaf-length, leaf-width, leaf-weight, stem-weight, herb yield, oil percentage and menthol content in representative samples selected randomly in each clone. Data were subjected to D^2 and canonical models of multivariate analysis for evaluation of genetic divergence among test genetypes to Eberhart and Russell's (1966) model and Perkins and Jinks' (1968) model of stability analysis for G×E interactions and stability parameters and to standard methods of correlation coefficients at phenotypic, genotypic and environmental levels for constructing a suitable selection index. Simple ANOVA with orthogonal partitioning of variances was employed to analyse irradiated progenies.

Salient findings are succinctly assembled herein :

1. A substantial amount of genetic variability seems to have been added to *M. arvensis* owing to active processes of natural evolution during the last two and a half decades of Japanese mint cultivation in India. This is borne out by following three facts based on multivariate analyses :

(a) The D^2 values for any pair of populations were tremendously large, ranging from 10.4 to 1752.4 at Lucknow and 44.1 to 6308.3 at Pantnagar;

(b) The number of groups obtained from 30 clones were high at both Lucknow snd Pantnagar conditions with 11 and 13 clusters, respectively; and

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(c) Inter-cluster divergence was considerably high, ranging from 121.67 to 1473.00 at Lucknow and 215.00 to 1358.30 at Pantnagar.

This was broadly confirmed by relative distribution of 30 clones in two diamentional λ_1–λ_2 chart under canonical analysis as well.

2. The differentiation among genotypes was nearly complete in two axes of differentiation accounting for more than 80.00% of total variation under both Lucknow and Pantnagar conditions.

The major forces of differentiation at primary axis at both the locations were remarkably the same, viz., leaf-width, leaf-length and plant height. The plant height was an important factor of differentiation at secondary axis also. Leaf weight was the other important factor.

3. In G × E interaction study, the variation due to interaction was found to be substantially high (P. 0.01). This implies that test genotypes in point, manifested striking differential response to fluctuating environments. In other words the crop is very highly sensitive to environment, particularly the cultural practices.

4. Both linear and non-linear components of G × E interaction were highly significant for all the traits examined. However, former was more predominant than the latter indicating thereby reasonable predictability of phenotypic performance under diverse environments. But reverse was true for menthol content which may be attended to by highly unpredictable response to environments since G × E (linear) was smaller than G × E (non-linear) or pooled deviation.

5. A positive correlation between the genotype means and regression or deviation from linearity for all traits except menthol, may lead to the choice of high yielding genotypes coupled with low stability. This was probably because of considerable influence of non-linear sensitivity. However, the negative correlation with menthol content suggested that clones with high menthol content along with high stability can be selected for a happy proposition.

6. Based on mean performance and linear sensitivity all the 30 clones could be classified into two major adaptive specificities : general adaptability and specific adaptibility. Thus, the culture 1316 followed by 1315 and IC 310 were found to be generally adapted over a range of environmental conditions with respect to herb yield, whereas

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cultures 1244, 45, 1532, 548 and 625 were found to be specifically adapted to rich environmental conditions. Culture 1315 was found to be well adapted to rich environmental condition with respect to oil content and generally adapted to all the conditions for menthol content as well culture 1315 was generally adapted for herb yield. Thus, it would appear that culture 1315 may be a suitable choice for wide cultivation of *M. arvensis*.

7. As an effective criterion of selection for high oil yield per unit area, the leaf-width was found to be a suitable market. This was positively correlated with oil content and so also with herb yield. The latter was again positively associated with oil content. Moreover, the leaf-width is an easily discernable and scorable trait, hence useful for visual (primary) selection.

8. Irradiation of culture 1316 with gamma-rays caused stimulation of vigour resulting in high herb yield in case of certain individual mutants at 1, 3 and 5 Kr doses. Thus, the mutants M_{101}, M_{302} and M_{501} for herb yield; M_{101}, M_{502} and M_{503} for oil content, and M_{101}, M_{301} and M_{502} for menthol content, were found to be better than the parental check. M_{101} was, however, the most promising mutant with respect to all the three economic traits mentioned above.

9. The basic requirements of an effective selection for the improvement of vegetatively propagated crops like *M. arvensis* have been discussed. The probable cause for generation of spontaneous variability and for wide adaptation have also been discussed along with possible breeding strategy for genetic upgradation of *M. arvensis*.

TISSUE CULTURE STUDIES ON MUNG
(Vigna radiata L. Wilczek)

Ravi Pratap Singh *Sup. : Dr. B. D. Singh*

Plant tissue culture concerns with maintenance and culture of plant parts, organs and cells in artificial media. This technique is extensively utilised in crop improvement, production of medicinal compounds, biotransformation and somatic hybridization. Legumes are the chief source of vegetable protein. Tissue culture studies on this group of plants are generally limited to nutritional and biochemical studies. Mung (*Vigna radiata* L. Wilczek), is a valuable pulse crop

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grown throughout the year and is extremely useful in improving soil nitrogen status through symbiotic nitrogen fixation. The present work was undertaken to establish callus cultures of mung and exploring the possibility of regeneration of plantlets. Polyphenol accumulation, enzyme activities (peroxidase, polyphenol oxidase, nitrate reductase and nitrite reductase) and peroxidase isozymes were also studied in mung callus cultures grown on various media.

Mung callus was initiated from root, shoot and hypocotyl explants of 3-day old seedlings. Shoot explants were more prone to callus formation; B_5 medium containing 0.1 μg ml^{-1} kinetin and 1 μg ml^{-1}2, 4-D was the most suitable for initiation of callus. The combination of 1 μg ml^{-1} of each of 2, 4-D and kinetin was suitable for callus growth. Casein hydrolysate 4 gl^{-1} gave the highest fresh and dry weights, followed by 2 gl^{-1} casein hydrolysate and 100 ml 1^{-1} coconut water. Agar at a concentration of 0.8% was suitable for callus growth. Sucrose 20-40 gl^{-1} and glucose 20 gl^{-1} was appropriate for mung callus growth. Several amino acids were tested for their effect on growth of calluses; arginine was the best amino acid closely followed by glutamine (2 gl^{-1}) and ornithine (0.5 gl^{-1}). Methionine and phenyl alanine were strongly inhibitory to mung callus growth. Callus growth was significantly higher in phosphate (0.02 M) and succinate (0.002 M) buffered media, while acetate buffer strongly inhibited callus growth. Callus initiation and callus growth was better in LGG 127 than in the other genotypes.

Root regeneration was favoured by a low concentration (0.1 μg ml^{-1}) of 2, 4-D. Higher concentrations of 2, 4-D and kinetin inhibited root regeneration, while NAA and IAA favoured root regeneration upto 1 μg ml^{-1}. NAA was more potent in inducing root regeneration than IAA from callus tissue. Root regeneration potential was more in LGG 127 than in the other genotypes. Addition of glutamine at low concentrations of 2,4-D and kinetin increased the frequency of root regeneration. Root regeneration from regenerated shoots was the maximum in medium containing 1 to 2 μg ml^{-1} IAA or 2 μg ml^{-1} NAA. The presence of gibberellic acid inhibited root regeneration from regenerated shoots. Sucrose at 20 gl^{-1} and $CaCl_2$ at 150 mg 1^{-1} were appropriate for root regeneration from regenerated mung shoots. Shoot regeneration was observed after 10-15 days of incubation from macerated shoot tips in B_5 medium containing benzyl adenine (0.1-0.5 μg ml^{-1}) with NAA or IAA (0.1-0.5 μg ml^{-1}). IBA showed poorest shoot regeneration, while 2, 4-D inhibited shoot regeneration at all

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concentrations. The presence of gibberellic acid (0.5-1 $\mu g\ ml^{-1}$) in shoot regenerating medium enhanced shoot regeneration. Out of twenty mung genotypes screened, LGG 127 followed by Lm 535 and T 44 showed better shoot regenerating potential than the others.

Polyphenol accumulation was inversally correlated with 2,4-D concentration, while a higher concentration of kinetin promoted polyphenol accumulation in callus tissues. Coconut water, casein hydrolysate, arginine and glutamine significantly reduced polyphenol accumulation, while yeast extract, phenyl alanine and methionine had a noticeable promotory effect. ML 5 and Li 8 showed higher polyphenol contents than the other genotypes. Generally, buffering of the B_5 medium increased polyphenol content in callus tissue; the effect of acetate was greater than the other buffers. Polyphenol content and enzyme activities increased in fast growing phase of the callus tissue. Peroxidase and polyphenol oxidase activities increased with decrease in 2,4-D and kinetin concentrations and was maximum in medium lacking 2,4-D. On the other hand, protein content was high at 1 $\mu\ ml^{-1}$, each of 2,4-D and kinetin. Yeast extract, serine and alanine enhanced peroxidase activity. LGG 127, K 851, PS 16 and ML 26 showed higher protein contents than the other genotypes. Peroxidase and polyphenol oxidase activities were greater in Li 8, ML 5 and TT9E and lower in K 851 and LGG 127. Succinate buffered medium enhanced peroxidase and polyphenol oxidase activities. Nitrate reductase and nitrite reductase activities were higher at 0.1 $\mu g\ ml^{-1}$ each of 2,4-D and kinetin, the higher concentration of kinetin slightly depressed nitrate reductase activity. Presence of glutamate along with respective enzyme substrate increased nitrate reductase activity and decreased nitrite reductase activity. Nitrate reductase and nitrite reductase activities were more in callusses obtained from phosphate and succinate buffered media.

Variation in appearance of isozymes was seen in the various treatments and the genotypes. Isozymes D, E and A were common in most of the treatments and varieties. Some isozymes, viz., A_2 and B_1 appeared in media having no or low concentrations of 2,4-D and kinetin. Callusses obtained from yeast extract containing media showed the maximum number of isozymes (9). Succinate buffered media also showed some new isozymes, viz., A_3 and D_2.

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BIOCHEMICO GENETIC BASIS OF DWARFNESS IN RICE AND WHEAT

Yashawant Singh *Sup. : Dr. B. D. Singh*

The introduction of semidwarf wheat and rice strains are mainly responsible for their increased production per unit area in India. The dwarf stature is a favourable characteristic leading to lodging resistance and better crop responses to agronomic practices. In the present study Biochemico Genetic Basis of Dwarfness was investigated in certain semidwarf strains of rice and wheat. Thirtynine and thirtythree semidwarf and tall strains of wheat and rice, respectively, were subjected to GA_3 spray. The study was conducted with three replications in Split-Plot Design in two years. In wheat each strain was treated with 0.25, 50, 150 and 250 ug/ml GA_3, where as in rice 0, 10, 20 and 50 ug/ml GA_3 were sprayed; data were recorded for eight characters viz. plant height, tiller number, panicle length, number of internode, days to flowering, days to maturity, total yield/5 plants and test weight in both crops. The endogenous GA_3 was estimated by the method of Radley (1970). The bioassay of gibberellin was done by the procedure of Nicholls and Paleg (1963). The amylase activity was estimated according to the method of Bernfeld (1953). Selected crosses were made and seggregating pattern in F_2 and F_3 families were studied for the inheritance of dwarfness and GA insentivity; character association among yield and yield traits were also undertaken to see the impact of varying concentration of GA_3 on correlation coefficients.

The studies revealed that plant height significantly increased in the tall and semidwarf strains C'-4-1, B 2-4, B 23-1 and WMJS 9, while other semidwarf strains did not respond to exogenous GA_3. On the basis of their GA_3 response, two tall, 7 nonresponsive and 5 responsive semidwarf strains were used for determination of endogenous GA content. The GA_3 responsive semidwarf strains showed considerably lower GA content than the tall strains. Therefore, these strains are supposed to have a partial block in GA biosynthesis. On the other hand, the GA_3 nonresponsive semidwarf strains showed several-fold higher endogenous GA content than the tall cultivars. On the basis of these findings it was concluded that the GA_3 nonresponsive strains have a partial block in GA utilization.

In case of rice, 3 tall and 30 semidwarf strains were sprayed with 10, 20 and 50 ug/ml GA_3, and a total of 5 GA_3 sprays were given. The first spray was given 15 days after transplanting. GA_3 application significantly increased plant height in the tall and 28 of the semidwarf

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strains. Semidwarf strains Shyama and Cigar Mutant did not respond to exogenous GA_3. For determination of endogenous GA_3 content, 3 tall, 9 GA_3 responsive and 2 GA_3 nonresponsive strains were selected. The level of endogenous GA content in GA_3 responsive strains was much lower than that in the tall strains; these semidwarf strains are proposed to have a restriction on GA biosynthesis. The GA_3 nonresponsive semidwarf strains Shyama and Cigar Mutant, on the other hand, showed much higher levels of endogenous GA than the tall strains. These two strains are, therefore, supposed to have a restriction on GA utilization. In both rice and wheat, some semidwarf strains showed restriction on GA utilization, while others showed restriction on GA biosynthesis.

Amylase activity in germinating seeds was determined in all strains which were used for determination of endogenous GA content both in the case of rice and wheat. Amylase activity in germination seeds showed considerable variation from one strain to the other. The amylase activity did not appear to be associated with either plant height or GA_3 responsiveness of the strains. There was a significant negative correlation between endogenous GA content and amylase activity. It is interesting that although applied GA_3 is known to promote amylase activity in germinating seed, endogenous GA had a depressing effect on amylase activity.

Effect of GA_3 on amylase activity in germinating seeds was studied in some strains in which amylase activity was determined. The seeds were germinated in presence of 1 ug/ml GA_3 and amylase activity was determined after 5 days. In case of wheat, all the strains, except C'-3-1, showed a considerable increase in amylase activity in response to GA_3. The behaviour of C'–3–1 is similar to that of *Gai/Rht* 3. In case of rice, the tall and GA_3 responsive semidwarf strains showed a considerable GA_3 response, while Cigar Mutant and Shyama, which were GA_3 nonresponsive in terms of plant height, did not show any effect of GA_3 on amylase activity as well. Thus, their behaviour was comparable to that of C'–3–1 semidwarf strain of wheat and to *Gai/Rht* 3.

In case of GA_3 responsive semidwarf strains, B 23–1, C''–12–1, B 2–4, C'–4–1 were crossed with K 68, Kalyan Sona, and Sonoro–64 to determine the patten of inheritance. All the F_1's were tall, but F_2 distribution was continuous, making it impossible to reduce the nature of genetic control of semidwarfness in these strains. Howevere, it was clear that the gene or genes for semidwarfness in the GA_3 responsive wheat,

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semidwarf strains were nonallelic to *Rht* 1 or *Rht* 2 present in Kalyan Sona and Sonoro–64, respectively.

In case of rice, the GA_3 nonresponsive semidwarf strains Shyama and Cigar Mutant were crossed with Adamchini, T 141 (both tall) and with Dee-geo-woo-gen. In all the cases, the F_1 was tall and GA_3 responsive (crosses with T 141 and DGW only). Obviously, the gene for semidwarfness and GA insensitivity is recessive to the normal allele, and is nonallelic to that found in DGW. Although, the F_2 distribution was continuous, classification of F_3 progenies on the basis of their GA_3 responsiveness yielded 3:1 ratio. This shows a monogenic control of semidwarfness in Cigar Mutant and Shyama. The F_1 from crosses Shyama x Cigar Mutant was tall suggesting that the gene for semidwarfness in both the strains are non allelic to each other. In F_2 progenies, the ratios of GA_3 responsive to GA_3 nonresponsive progenies was 9:7, thus further, confirming that the genes for semidwarfness and GA_3 insensitivity in the two strains are nonallelic.

In rice, GA_3 application significantly affected some yield traits. Such as panicle length, days to maturity, tiller number, number of internodes and total yield, while days to flowering and test weight were not affected by GA_3 application. In case of wheat GA_3 spray significantly affected tiller number, days to flowering and grain yield/5 plants; number of internode, panicle length, days to maturity and test weight were not affected by exogenous GA_3. In general GA_3 had a deleterious effect on grain yield; this effect was particularly noticeable at 50 ug/ml GA_3 in case of rice and 150 and 250 ug/ml GA_3 in case of wheat. GA_3 application, in general, reduced the number of days to flowering. But in case of tiller number GA_3 had a variable effect; in some cases GA_3 application increased the tiller number while in other cases, there was a significant decrease. There was a strong effect of genotype on the GA_3 response; the different strains had different threshold of GA_3 concentrations.

Effect of GA_3 application on character association was studied both in wheat and rice. In all the cases GA_3 application did not change the direction of character associations. But in many cases, the magnitude of correlation coefficient was affected to some extent. In most of the cases, however, where correlation coefficients were significant; GA_3 spray appear to have no effect on the significance of correlation coefficient. In a few cases the correlation coefficients were significant either in control or in one or few GA_3 concentrations only. It appears safe to conclude that GA_3 application does not have a marked and predictable effect of character associations in rice and wheat.

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HORTICULTURE

EFFECT OF PLANTING DENSITY, NITROGEN AND CYCOCEL ON THE GROWTH, FRUITING AND FRUIT QUALITY OF TOMATO (*Lycopersicon esculentum Mill.*)

Braja Kishore Pattanayak *Sup. : Dr. C. B. S. Rajput*

The present investigation, entitled "Effect of Planting Density, Nitrogen and Cycocel on the Growth, Fruiting and Fruit Quality of Tomato (*Lycopersicon esculentum* Mill.", was conducted on Pusa Ruby cultivar during 1980-82. Field experiments involving three levels each of planting density (37037, 27777 and 22222 plants/ha), nitrogen (0, 60 and 120 kg/ha) and cycocel (0, 1000 and 2000 ppm) were carried out at the Vegetable Experimental Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. A split plot design, keeping planting densities in main plots, nitrogen levels in the sub-plots and cycocel in the sub-sub-plots, with 3 replications, was adopted.

Observations were recorded on growth characters, such as, plant height, girth of the main stem, number of branches and leaves per plant, fresh and dry weight of shoot and root, length and number of roots per plant. Flowering and fruiting characters studied included days to flowering and ripening of fruits, number of flowers and fruit set per plant, yield per plant and hectare, mean fruit weight and number of ripe fruits harvested per plant. Lastly, the observations recorded in respect of the physico-chemical composition of tomato fruits were, fruit height and diameter, fruit specific gravity, number of seeds per fruit, storage life of fruits after ripening under room conditions, total soluble solids, titratable acidity, ascorbic acid, reducing, non-reducing and total sugar contents.

Plant growth, expressed in terms of height, main stem girth, number of branches and leaves, was greatly influenced by the medium planting density (27777 plants/ha). Other characters like fresh and dry weight of shoot and root development were best at the low planting density (22222 plants/ha). Commencement of flowering and fruit ripening were earliest at the medium planting density. Number of

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flowers and fruit set were maximum at the low planting configuration, while yield and number of ripe fruits harvested per plant attained maximum values at the medium planting density. Yield per hectare and average weight of ripe fruits were maximum at the high planting density (37037 plants/ha). Important fruit characters like size, storage life, total soluble solids were highly influenced by the low planting density. And fruit specific gravity, titratable acidity and ascorbic acid contents rose at the medium planting density. At the high planting density, seed number per fruit and fruit sugar contents were observed to be maximum.

Similarly, nitrogen at high levels (120 kg/ha) contributed towards the best vegetative growth of tomato plants. It also greatly improved earliness, number of flowers and fruit set, yield of fruits, mean fruit weight and number of ripe fruits harvested per plant. The physico-chemical composition of fruits was also remarkably affected by nitrogen supply. Fruit size, titratable acidity, T. S. S. were maximum at high nitrogen levels. But seed number, storage life, reducing sugar and total sugar contents of fruits rose at the low nitrogen level (60 kg/ha). Specific gravity, ascorbic acid and non-reducing sugar of fruits considerably declined with nitrogen supply.

The effect of cycocel was very consistent in retarding the tomato plant height. Decrease in the main stem girth and number of leaves per plant was also observed in the treated plants. But cycocel at low concentration (1000 ppm) improved root growth and branch numbers per plant. Fresh and dry weight of shoot and root were maximum at high cycocel concentration (2000 ppm). Earliness in respect of commencement of flowering and fruit ripening was greatly advanced with increase in the cycocel concentration. Yield per plant and hectare, number of ripe fruits harvested per plant attained maximum values at high cycocel concentration. Number of flowers and fruit set were influenced by cycocel application. The mean weight of fruits declined on the cycocel treated plants. Fruits of maximum height were observed at low concentration, whereas fruit diameter declined gradually with increase in the cycocel concentration. Storage life, T. S. S. and sugar contents of fruits were found to increase at low levels. Fruit specific gravity was maximum at the high cycocel concentration. However, the seed number, titratable acidity and ascorbic acid content of fruits gradually declined in the fruits of treated plants.

The two factor interactions between planting density, nitrogen and cycocel produced significant results relating to the growth, fruiting,

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fruit quality characters in tomato. The planting density x nitrogen combination produced promising results in respect of the over all plant vegetative growth, earliness, number of flowers and fruit set per plant, yield, average fruit weight and number of ripe fruits harvested per plant, fruit size, titrateable acidity, ascorbic acid and sugar contents. Fruit specific gravity was influenced by the planting density x cycocel interaction. Storage life, seed number and total soluble solids of fruits were greatly improved by the nitrogen x cycocel interaction.

Plant growth pertaining to the height, number of branches and leaves was best at the combination of medium planting density, high nitrogen and no cycocel (27777 plants/ha, 120 kg N/ha, O ppm CCC). Similarly the length and number of roots per plant were maximum at high planting density, high nitrogen and low cycocel, and high planting density, low nitrogen and low cycocel respectively. Maximum fresh and dry weight of shoot and root were obtained from treatment combinations of high planting density and low nitrogen at high cycocel concentration.

Commencement of fruit ripening, number of flowers and fruirt set per plant were maximum at medium planting density (27777 plants/ha) high nitrogen (120 kg/ha) and high cycocel concentration (2000 ppm). Yield per plant and number of ripe fruits harvested per plant attained highest values at medium planting density (27777 plants/ha) and high nitrogen level (120 kg/ha) at low cycocel level (1000 ppm) combination. The mean fruit weight was maximum at high planting density (37037 plants/ha), high nitrogen and low cycocel combination. The highest yield of ripe tomato fruits per hectare was obtained from the treatment combinations of high planting density, high nitrogen without any cycocel (37037 plants/ha, 120 kg N/ha and O ppm CCC).

Best sized fruits were obtained from the combination of high planting density, high nitrogen and low cycocel. Fruit specific gravity was highest at medimum planting density with high cycocel and no nitrogen supply. Seeds in the fruit were maximum at medium planting density, low nitrogen without nitrogen combinations. Storage life of ripe fruits was longest at the combination of high planting density, low cycocel without cycocel and minimum at medium planting density low cycocel with atnitrogen. Fruit reducing sugar content was maximum at high planting density, low nitrogen and low cycocel combination. Similarly, total soluble solids in the fruits rose at the low planting density, high nitrogen and low cycocel level. Fruit

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ascorbic acid content was maximum at medium planting density, low nitrogen without cycocel.

Yield of fruits exhibited positive and significant correlation coefficients with characters like plant height, girth of the main stem, number of branches and leaves per plant, fresh weight of shoot and root, number of flowers and fruit set per plant, mean fruit weight and number of ripe fruits harvested per plant. Among all, the last character showed the strongest association with yield giving correlation coefficients of +0.9615 and +0.9566 in first and second crop, respectively.

Basing on the experimental evidences, the following conclusions can broadly be drawn for obtaining a good tomato crop. A planting density of 27777 plants and nitrogen dose of 120 kg per hectare with 1000 ppm cycocel as foliar spray, are most suitable for the best performance in Pusa Ruby tomato cultivar for the best growth, highest yield of quality fruits.

BIOMETRICAL STUDY OF YIELD, YIELD COMPONENTS AND SOME QUALITY TRAITS IN CHILLIES (*Capsicum annuum* L.)

Chandrika Ram Gupta *Sup. : Dr. V. S. Chhonkar*

The present investigation was undertaken with chillies to study, the nature and magnitude of gene effects, combining ability variances and effects, heterosis, inbreeding depression and character associations in respect of twelve characters related to yield and quality, viz., plant height, number of primary branches, number of secondary branches, fruit length, fruit girth, fruit weight, fruits number per plant, ripe fruit yield per plant, dry fruit yield per plant, harvest index, ascorbic acid content and capsaicin content. Eight diverse cultivars of chillies, viz., Kovilpatti-2, CA (P) 247, Sindhoor, JCA-154, Maghi, Kalyanpur Chaman, Kalyanpur Chanchal and Pant C-1, belonging to spices (erect and pendent) and pickle groups were chosen in the present study.

Diallel crosses were made in all possible combinations (excluding reciprocals). The experiment was laid down with eight parents, 28 F_1s and 28 F_2s, in a randomized block design having three replications, at Vegetable Research Farm, Department of Horticulture, Banaras Hindu University, Varanasi, during August 1980 to February 1981.

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Observations for metric traits were recorded on ten competitive plants per plot from each of the parents and F_1s, and on 50 plants from each of the F_2s, from each replication. Estimations of quality traits, viz., ascorbic acid and capsaicin content were done on per plot basis from each replication.

Plot means of the different characters were used for statistical analysis, following technique suggested by Panse and Sukhatme (1967). The graphic and component analyses of the diallel crosses were performed by the methods of Jinks (1954) and Hayman (1954) for F_1s and Jinks (1956), Hayman (1958) and Mather and Jinks (1971) for F_2s. For combining ability analysis Griffing's (1956) Method-2 and Model I, was adopted. The results of the present investigation are summarised below.

The mean sum of squares for the different characters were significantly different in all the populations, showing maximum differences among the parents and crosses.

The graphic analysis revealed partial dominance for all the characters, in both the generations. The parents JCA-154, Kalyanpur Chanchal and Pant C-1 possessed higher concentration of dominant alleles for majority of the traits studied.

The nonsignificant of 't^2' values for all the characters, except for number of secondary branches (F_1 and F_2), fruit length (F_1) and fruits number plant (F_1 and F_2) showed that the Wr-Vr values were homogeneous and thus the assumptions in diallel analysis were satisfied.

The analysis of the components of genetic variance revealed that the additive component (D) was highly significant for all the characters, in both the generations, except for number of primary branches in F_2 generation. The nonadditive component (H_1 and H_2) were also significant for all the characters in both the generations, except for number of secondary branches (F_2) and fruit weight (F_1 and F_2). This suggested the importance of both additive and nonadditive gene effects in the present materials. The estimates of h^2 were positive for most of the characters, and significant in case of fruits number, ripe fruit yield, harvest index (F_1s), dry fruit yield and capsaicin content (F_1 and F_2). The estimates of F component was positive and significant for capsaicin content in both the generations, revealing an excess of dominant gene controlling this trait.

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The estimates of mean degree of dominance $(H_1/D)^{\frac{1}{2}}$ were more than unity for number of primary branches, number of secondary branches, fruit length (F_1 and F_2), plant height, fruit girth, fruit weight, yield, harvest index and ascorbic acid content (F_2), suggesting over dominance for these characters. The estimates $H_2/4H_1$ suggested asymmetrical distribution of positive and negative alleles for most of the characters. The ratio K_D/K_R indicated predominance of dominant alleles among the parents. The ratio h^2/H_2 was less than unity for most of the characters, except for dry fruit yield, harvest index and capsaicin content (F_1) indicating one to two genes/groups of genes controlling these characters.

The high estimates of heritability (narrow sense) was observed for capsaicin content, ascorbic acid content, yield (ripe and dry) and fruits' number, and other characters had low to moderate heritability.

The combining ability analyses indicated that the GCA and SCA variances were highly significant for all the characters in both the generations, and the former being usually larger in magnitude. The discripancy in the estimates of proportions of additive and dominance components as obtained from the graphic component and combining ability analyses have been discussed.

The GCA effects were positively associated with *per se* performance of the parents for most of the characters studied. Parents Kovilpatti-2 and Maghi were the superior general combiner for plant height, Kovilpatti-2 and Pant C–1 for more number of primary branches, Kalyanpur Chanchal and Pant C–1 for high number of secondary branches whereas Kalyanpur Chaman, Maghi and Sindhoor were best general combiners for fruit length, ripe fruit yield, dry fruit yield and harvest index. For fruit girth Maghi and JCA–154 and for fruit weight Maghi and Sindhoor were the best general combiners. Considering fruit snumber, the parents Kalyanpur Chanchal and Pant C–1 were to be general combiners. For quality traits parents Pant C–1 and Sindhoor were superior for ascorbic acid content and capsaicin content.

The estimates of SCA effects, in general, revealed that most of the cross combinations indicated significant positive SCA effects involving either one good and one poor or both poor general combiners. Relatively higher estimates of SCA effects were usually recorded in those crosses which involved diverse interacting parents.

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Heterosis was estimated over better parent (Heterobeltiosis) and mid parent for twelve characters. Better parent heterosis ranged from 8.9 per cent to 17.9 per cent for dry fruit yield and 6.4 per cent to 12.3 per cent for dry fruit yield. None of the crosses showed significant positive heterosis over better parent for ascorbic acid and capsaicin content. Significant heterosis as well as inbreeding depression was observed in many crosses. The cross combination of K. Chanchal x Pant C–1 exhibited higher heterosis over better parent for fruit number and ripe fruit yield and showed low inbreeding depression for these traits.

The correlation coefficients revealed that significant association at phenotypic level between characters, were mostly due to genetical causes. Yield (dry and ripe) showed significant positive association with plant height, fruit length and furit weight at both genotypic and phenotypic levels. Capsaicin content showed significant and positive association with ascorbic acid. Ascorbic acid and capsaicin contents were positively and significantly correlated with number of secondary branches and fruits number per plant, whereas the association was nonsignificant with yield. The degree of association among most of the characters reduced in F_2 than F_1s.

In view of the results obtained in this investigation and also in view of their implications in breeding suitable genotypes, following suggestions are made to plan an efficient breeding programme for concommitant improvement in the yielding potential and quality of chillies.

(i) Diverse parents should be selected on the basis of *per se* performance and combining ability effects for the different characters. The cultivars which have proved their superiority over others as indicated above, may be utilised with advantage for improvement in chillies.

(ii) Reciprocal recurrent selection or full sib selection or other population improvement coupled with isolation of fixed lines from advanced generations may be employed. Standard selection procedures (isolation of pure lines) may be adopted for the traits primarily controlled by additive genes.

(iii) Selection should be practiced on the basis of respective weights of the different component characters for avoiding genetic slippage.

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(iv) Isolation of male sterile lines need to be established for the exploitation of heterosis and for commercial heterotic breeding by utilising the natural out crossing existing in this crop.

(v) A recurrent selection procedure may be followed in the heterozygous population derived from the cross of divergent parents to improve both the quality traits (Vitamin C and Capsaicin content) simultaneously.

GENETIC ANALYSIS OF YIELD AND YIELD TRAITS IN BRINJAL *(Solanum melongena* L.)

Ramesh Singh *Sup, Dr. A. N. Maurya*

The present investigation was undertaken to study the nature and magnitude of gene effects, combining ability variance and effects, heterosis, inbreeding depression and character associations for plant height, length of leaves, width of leaves, number of branches, fruit length, fruit diameter, number of fruits per plant, weight of fruit and yield per plant in Brinjal.

Non reciprocal crosses involving nine diverse cultivars of brinjal namely, Pusakranti, 202-9, 75/8, Arkakusmakar, Pusa Purple Round, PH-4, BR-112, Nurki, Muktakeshi belonging to different height and yield groups were studied. Thirty six F_1s and 36 F_2s alongwith 9 parents were transplanted in a randomized block design in three replications at the vegetable research farm, Department of Horticulture, Banaras Hindu University, during 1979 to 1982. Ten plants were selected from each plot to record observations in respect of parents and F_1s whereas fifty plants were taken from each of the F_2s from each replication for the study of various characters.

Plot means of the different characters were used for statistical analysis. Analysis of variance was performed following the technique suggested by Panse and Sukhatme (1967). The graphic and component analysis of the diallel crosses were performed by the methods of Jinks (1954) and Hayman (1954a) for F_1 and Jinks (1956), Hayman (1958) and Mather and Jinks (1971) for F_2. For combining ability analysis Griffing's (1956b) Method 2 and Model I was adopted. The results of the present investigation are summarised below :

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(1) The mean sum of squares for all the characters were highly significant in all the populations showing differences among the parents and crosses.

(2) The graphic analysis revealed partial dominance for plant height, length and leaves, width of leaves, number of branches, fruit length, number of fruits per plant, and over dominance for yield per plant in both the generations.

(3) The nonsignficance of t^2 values for all the characters except plant height, length of leaves, width of leaves (F_2) and fruit diameter and yield per plant (F_2) showed that Wr-Vr values were homogeneous and, thus, the assumptions for the diallel analysis were satisfied.

(4) The additive component ($\hat{D}$) of genetic variance was significant for most of the characters in both the generations except for fruit diameter and yield per plant (F_2s) and number of branches (F_1s, F_2s). The two measures of nonadditive components of genetic variance ($\hat{H_1}$ and $\hat{H_2}$) were also significant for all the characters studied. This suggested the importance of both additive and nonadditive gene effects for controlling yield and its contributing traits in the present material. However, the estimates of nonadditive component ($\hat{H}_1$ and $\hat{H}_2$) were relatively higher in magnitude than the estimates of additive component ($\hat{D}$) for all the characters.

(5) The estimates of the third measure of nonadditive component ($\hat{h^2}$) were positive in many of the characters but was nonsignificant for all the characters in both the generations except for number of fruits per plant.

(6) The $\hat{F}$ component was positive and significant for number of fruits per plant and weight of fruit (F_1), revealing an excess of dominant genes controlling these characters.

(7) The estimates of degree of dominance were higher than one for all the characters studied in both the generations, suggesting over dominance except for weight of fruit (F_1) for these characters.

(8) The estimates of the ratio $\hat{H}_2/4\hat{H}_1$ were not close to unity for majority of the characters suggesting asymmetrical distribution of positive and negative genes. The ratios which give the relative proportion of dominant and recessive genes were higher than unity for all the characters except for plant height in both the generations

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and length of leaves (F_1 only) indicating an excess of dominant genes in controlling these characters.

(9) The ratio $\hat{h}_2/\hat{H}_2$ which indicates the dominance gene groups/genes controlling the characters revealed that a fewer number of gene groups/genes controlled the characters studied.

(10) High heritability estimates were observed for weight of fruit (109.945 and 36.428 per cent), and number of fruits per plant (70.924 and 18.505 per cent) in F_1 and F_2. For the remaining characters heritability estimates were low to moderate.

(11) The GCA and SCA variances were highly significant for all the characters except for fruit diameter (F_1s) and the former being usually larger in magnitude. The discrepancy in the estimates of proportions of additive and dominance components as obtained from the graphic, component and combining ability analysis have been discussed.

(12) The GCA effects were positively associated with the *per se* performance of the parents for most of the characters studied.

(13) Among the parents P_4, P_5 and P_8 were the superior general combiners for plant height, P_8 and P_5 for fruit diameter, P_4 and P_8 for more number of fruits per plant, P_2, P_5, P_7 and P_9 for fruit weight and P_5 and P_9 for more yield per plant were the top general combiners.

(14) Considering both the *per se* performance and GCA effects together parents P_4, P_6 and P_9 were found to be the best parents for number of fruits as well as fruit length.

(15) The estimates of SCA effects in general were lower in magnitude in the F_2s. Most of the crosses showing significant positive SCA effects involved one good and one poor or even negative general combiners.

Relatively higher estimates of SCA effects were usually recorded in those crosses which involved diverse interacting parents.

(16) Heterosis was estimated over better parent and mid parent for nine characters. Better parent heterosis ranged from 1.211 to 202.748 per cent for weight of fruit, whereas for yield per plant the better parent heterosis ranged from 6.928 to 177.384 per cent.

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Inbreeding depression for yield per plant ranged from 76.970 to 68.077 per cent for other characters also significant heterosis as well as inbreeding depression was observed in many crosses.

(17) The cross combination of P_4 a high yielding and clustered variety and P_6 exhibited high heterosis for weight of fruit and yield and showed comparatively low inbreeding depression.

(18) The correlation coefficients (genotypic and phenotypic) revealed that significant associations at phenotypic level between characters were mostly due to genetical causes.

(19) The yield per plant was positively and significantly associated with plant height, width of leaves, number of fruits per plant and weight of fruit (F_1s and F_2s) except for length of fruit and these were main yield (F_1s) contributing characters.

In view of the results obtained in these investigations and also in view of their implications in breeding suitable brinjal varieties, it was observed that additive genetic variance is most important in the expression of the characters, viz., plant height and weight of fruit. Therefore, selection breeding would be more effective in the improvement of these characters. On the other hand, length of leaves, width of leaves, number of branches, fruit length, fruit diameter, number of fruits per plant and yield per plant were largely governed by non-additive genetic variance. Therefore, heterosis breeding would be more helpful for improving these traits.

The parents P_6, P_5 and P_4 were top general combiners for yield fruit diameter and fruit length, whereas P_2 was found to be best of all for dwarfness among the parents. For SCA effects out of 36 crosses the $P_4 \times P_9$ was recorded highest yielder followed by $P_4 \times P_6$, $P_6 \times P_9$, $P_4 \times P_5$ and $P_1 \times P_2$.

Crosses ($P_4 \times P_9$ and $P_4 \times P_6$) may be recommended for commercial use of hybrid vigour.

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STUDIES ON THE CHEMICAL WEED CONTROL IN CHILLIES *(Capsicum annuum* L.)

Balister Singh *Sup. : Dr. V. S. Chhonkar*

Vegetable growing is gaining popularity among the several branches of Horticulture. In recent years, the vegetables which are an important article of daily human diet, have been well recognised all over the world as a source of their chemical substances necessary for growth, reproduction as well as for maintenance. They are also important for neutralizing the acids produced from different sources of food in the body. Regular use of vegetables maintains supplies of numerous essential vitamins, minerals and other health growing substances to the body.

Looking into the potentialities of the herbicides in crop improvement the present experiment was undertaken to study the chemical weed control in chilli *(Capsicum annuum* L.) under the conditions prevailing in Varanasi region. The study would be of great benefit for the cultivators and vegetable growers of this tract where chilli is extensively grown and is a popular vegetable crop.

Present investigation was carried out on chillies crop employing 14 treatment combinations at the vegetable experimental farm of Banaras Hindu University, Varanasi, India during the years 1980 and 1681. These experiments were conducted using Randomized Block Design with three replications.

The treatment combinations showed significantly good responses on various plant growth characters and were found useful in controlling the weeds from chillies crop as compared with control. The maximum plant height, diameter of stem, number of branches and the minimum weed count were recorded when Tok E-25 was applied during pre and post-emergence. The highest fruit number and also the yield per plant as well as the yield per hectare were recorded under this treatment (T_8) within the chemicals used. The minimum yield was recorded in control group (T_{14}). Significantly higher yield ($P<0.01$) was recorded when hand-weeding was practiced (T_{13}) irrespective of the treatments given in chilli field.

Significant (<0.05) improvement in the diameter of fruit and the fruit length was found in T_8 group whereas the lowest value was recorded in T_{12} group among the chemicals used. Significantly

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superior ($P<0.05$) length and diameter of fruits recorded handweed group (T_{13}) when compared to other treatments.

Within the chemicals Tok E-25 was found to be the most economical and the next was Basalin when applied in different forms/doses. Igran both pre and post-emergence applications gave least income among the treatments. The lowest profit was recorded in control group when compared with other treatment groups. The results clearly show that due to the influence of various chemicals profit is significantly higher as compared to control.

Significant positive correlations were found from dry chillies weight to the height of plant, number of branches, number of fruits per plant and the length of fruit. But the values of dry chillies were negatively correlated with the weed count and fresh weight of weed.

On the basis of the results recorded in the present investigation it may sefely be concluded that Tok E-25 proved most profitable for chilli growers on economical level when applied after 2 days of transplanting (pre-emergence) as well as after 45 days of transplanting (post-emergence). Although, hand weeding gave the best results among treatments but for longer duration it will not be possible to arrange surplus labour at all the times. Therefore, Tok E-25 and Basalin can be used more economically to control the maximum weed population in chilli crop.

EEFECTS OF UREA AND GA_3 ON VEGETATIVE GROWTH, FLOWERING, FRUITING AND FRUIT QUALITY OF GUAVA *(Psidium guajava* L.)

Chandra Shekhar Rai *Sup. : Dr. B. P. Singh*

The guava *(Psidium guajava* L.) is one of the most important commercial fruit crops of India ranking fourth after mango, banana and citrus in area, production and popularity. It is well-known as poor man's fruit. There is hardly any other fruit crop which can compete with guava for its wide adaptability to varied types of soil, climates and cultural conditions. Its cultivation is not at all hampered by any one of the unfavourable situations which are so common in India such as extremes of temperature, hot winds,

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scanty rainfall, saline and poor soils, waterlogging conditions and above all, availability of fertilizer, water and other inputs.

Apart from above attributes, it is a fruit of high nutritive value. It is a rich source of vitamin C, good source of vitamin B complex, fairly rich source of vitamin A, calcium, phosphorus and other minerals. Availability of fruits at cheaper rates, almost throughout the year barring few summer months facilitates the running of processing industries with a higher margin of profit. It also occupies premier position among tropical fruits which bear crops more than one in a year. In mild climate of the tropics, guava can flower and fruit althrough the year without any specificity at the period provided water and temperature do not become limiting factors. In the regions, where the seasons are quite distinct due to variation in temperature or precipitation or both, specific period of flowering and fruiting are observed. In Northern India, two distinct flowering-spring (Ambe bahar) and rainy season (Mrig bahar) are observed. The fruits from these flowers ripe during rainy and winter seasons respectively, the latter being the main crop. This cropping behaviour has, therefore, enabled the growers to take either rainy season crop or winter season crop or both the crops in a year.

Plant processes are governed by many environmental factors. Mineral nutrition and application of growth regulators influence the change from vegetative to reproductive and vice versa. They serve to accelerate or retard plant growth, flowering, fruit-setting, fruit growth, yield and quality of the fruit. It is, therefore, obvious that a comprehensive knowledge of these nutrients, the amount and froms in which they are present in both soils and plants, their absorption and translocation, and seasonal distribution the roles that they play and their final utilization are of great importance to the growers and investigators. This has promoted the author to conduct the present investigation entitled "Effects of Urea and GA_3 on Vegetative Growth, Flowering, Fuiting and Furit Quality of Guava (*Psidium guajava* L.)". The experiments were carried out on 21-year old guava tree variety Allahabad Safeda at Horticultural Garden of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (India), during the year 1980-82. Treatments included urea (1, 2, 4 and 6%) and GA_3 (20 and 40 ppm) alone and in combination. A control was also included for comparison. There were 15 treatments in total, replicated thrice in a factorial randomized block design. A tree was taken as unit of treatment in a replication,

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thus making a total of 45 trees under the study. The chemicals were applied as foliar sprays in the second week of January and July in each year in spring and rainy season flushes, respectively. Observations on vegetative growth parameters, flowering, fruiting behaviour, fruit quality and nitrogen content of leaves were recorded. The recorded data were subjected to statistical analysis and the findings are presented and discussed in the present thesis. The experimental findings are summarised in the following paragraphs.

In general, foliar application of urea and GA_3 alone and as well as in combination have greatly influenced various characters which were studied.

Vegetative growth parameters such as length of terminal shoot, number of leaves and leaf area per terminal shoot were favourably influenced by urea treatments over control in both seasons and years. Number of flowers, fruit-set, fruit retention, diameter, fresh weight, dry weight and yield per tree were markedly improved while duration of flowering, fruit drop and average weight of seed per fruit was substantially reduced. Chemical composition of guava fruits were also improved. Nitrogen content of leaf was more under urea treatments. Higher concentration of urea was more pronounced in influencing the above characters than its lower concentration.

Application of GA_3 has greatly improved the vegetative growth parameters. The treatment recorded longer terminal shoots and larger number of leaves. Leaf area was also considerably increased by GA_3 spray as compared to control. Number of flowers, fruit-set, fruit retention, fresh weight, dry weight, diameter and yield per tree were considerably increased. Significant reduction in duration of flowering, fruit drop and average weight of seed per fruit over control was also recorded. Total soluble solids, ascorbic acid, reducing and non-reducing sugars and pectin were improved by GA_3 treatments. Acidity was reduced by 20 and 40 ppm GA_3 spray in both the seasons and years. Fourty ppm GA_3 was superior to 20 ppm GA_3 in spring and rainy season flushes of 1981 and 1982.

Combination of treatments of urea and GA_3 have proved better than individual treatments in influencing the various characters studied. Urea and GA_3 had a synergistic effect on the various characters studied.

On the basis of the results obtained in these investigations it could be concluded that urea (6%) in combination with GA_3 (40 ppm) proved best for improving the vegetative growth flowering, fruiting, fruit quality and nitrogen content of leaves in guava.

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STUDIES ON MORPHOLOGY, FLOWERING AND FRUITING OF APPLE CULTIVARS OF KASHMIR

Ashok Kumar Tiku *Sup. : Dr. C. B. S. Rajput*

Apple culture in Kashmir is old and with new introductions from time to time, it has gained tremendous importance that warrants understanding of genetic diversity. In the first place, with the help of ancient literature, it could be established that Kashmir is also one of the centres of apple culture along with European areas; and secondly, a systematic approach was built by investigating vegetative and floral morphology, fruit assessment for physico-chemical characters and indexing different varieties on new basis. For this purpose 61 varieties of apple (cultivars/varieties) were studied at Fruit Research Station, Shalimar, Kashmir, having the largest pool of both indigenous and exotic varieties and represents the most important source of genetic stock of the state.

The Pomological descriptions provided a high degree of variability vis-a-vis each variety differed far more than one subtle characters. The key prepared for quicker identification of the varieties has a wider applicability too, and can be of great importance in assessing the apple varieties beyond the present investigation. The leaf area, leaf shape, fruit characters especially the colour part were the chief lines chosen.

In apple flowers arise in cymose umbels and has an effective overlapping bloom of 6–16 days in March-April. The size of floral parts varied. Maximum flower opening occurred between 11.30 A. M. and 3.00 P. M., followed by observation from 6.30 P. M to 8.00 A. M., when critical night temperatures played part for majority of the varieties.

Apple pollen is elliptical in shape in all the varieties and the size varies between 16 and 20.5 μ. No distinction could be made with acetocarmine stain developed for the purpose (Tiku-Rajput or shortly TR stain) desired results could not be obtained.

There exists variation in leaf colour and thickness. Leaf colours identified were deep green, light green, green, their combinations and military green. Similarly, the leaf was thick, moderate thick and thin. Stomatal studies indicated a variation between 20.0 and 7.0 No's in density and 9 to 14.6 μ in size. Furthermore, on the basis of "stomatal survey" three broad groups (very vigorous, vigorous and semi-vigorous) for all the varieties were distinguished. This may prove helpful where the plant material is used as a rootstock and shall give some healthy information when used as scion.

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There was a distinct variation in internal and external characters of the fruit moreso, for colour pattern. Five new core designs (oblate, winged, cordate, scull and deltoid shapes) were identified. Juice colour assessment was done at the time of fruit harvest and a chart prepared wherein varieties were indexed. Though, this "colour indexing" is a new concept, hopefully much has been drawn by measuring its applicability as an additional or couplating factor to the existing norms.

The time of fruit maturity (optimal) differed with varieties, i. e., for early, mid and mid-late. This stage was determined with the aid of Swiss method, starch iodine test, fruit colour assessment, penetrometer method. A simple technique was also adopted "Tall" and "Fruit Sound' which gave comparatively better judgement. This needs to be appreciated widely.

An evaluation for malic acid, TSS, reducing sugars, total sugars, pH and vitamin C was done at the time of fruit harvest and each variety exhibited an individual trend.

Storageability varied for different varieties. Mid-late varieties had prolonged storage, e. g., in Ambri Kashmiri, Versified, Shabnam and Hybrid-17.

Colour assessment of twigs was done, differentiated into three basic groups, i. e. for deeply fuzzy, lightly fuzzy and free/nearly free. The fuzz was rubbed off and colour obtained thus, fitted into seven different groups and adopted as the primary mode of identification.

Among twenty-four new varieties the most preferred fruits were Shahi Delicious, Maharani, Shah Ambri, Sundhri, Malika, Royal Ambri, Shalimar Beauty, Lal Ambri and Shabnam.

While summing up, the most suitable variety as could be characterized by colour pattern and chemical constituents should possess, T. S. S. around 14 per cent, acidity around 0.1 per cent, pressure around 16 Lbs., pH around 5, total sugars around 8 per cent, vitamin C variable from 10 mg/100 g and above, and an envious red colour pattern (solid or striped or mixture of both). A distinct flavour and longer storageability are, however, the added qualities.

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EVALUATION OF HERBICIDES FOR WEED CONTROL IN ONION (*Allium cepa* L.)

Hari Wallabh *Sup. : Dr. V. S. Chhonkar*

Onion (*Allium capa* L.) is an important vegetable crop extensively grown in India for home consumption as for export purposes. Weeds play an important role in the yield potential in this crop and losses due to weeds have been reported to the tune of 90 percent (Shadbolt and Holm, 1956), 70-85 percent (Mani *et al.*, 1968). The control of weeds by physical methods, i. e., hoeing, etc , is costly, time consuming, difficult and ineffective due to close planting of onion seedlings which are vary sensitive to hoeing in the early stages of growth and frequent hoeing may result in injury to the roots (Bhagchandani *et al.*, 1973). Chemicals for weed control is a necessity in this crop. But, different recommendations for a particular herbicide by different workers suggest that a chemical giving good performance under one location may not give the same performance at other location. Hence a herbicide must be evaluated under specific conditions of climate and soil before recommending it to the farmers.

The study entitled "Evaluation of herbicide for weed control in onion was planned and carried out at Horticulture Research Farm, Banaras Hindu University, Varanasi, during Rabi season of the year 1980-81 and 1981-82. The objective was to find out some broad spectrum herbicides or their combinations for weed control in transplanted onion and to ascertain their effects on growth, yield, quality characteristics of onion, soil microflora and the effects of their residue on the succeeding crops.

The experimental soil was sandy loam, pH 7.29 and organic carbon 0.27%. The design during both the years was Randomized Block Design with three replications and fourteen treatments. The plot size was 3′ x 2′. Uniform 45 days old onion seedlings of Pusa Red variety were transplanted in the last week of December during both the years at a spacing of 15 x 10 cm. All treatments were fertilized with N, P and K at 120 60 and 50 kg/ha, respectively. The plots were irrigated immediately after transplanting and subsequently as and when required.

The pre-planting application of herbicides were carried out one day before transplanting with a hand sprayer fitted with fan-type nozzel. Fluchloralin was incorporated into the soil upto a depth of about 1½–2″ immediately after spraying. The post-emergence treatments were carried out 40 days after transplanting the onion seedlings.

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The weed density was recorded with 50 cm^2 quadrate per plot. The fresh and dry weight of weeds was also recorded at last weeding. Observations on plant height, number of leaves, phytotoxic effects on the crop, size of onion bulbs, mean weight of onion bulb, total soluble solids, total carbohydrates, ascorbic acid and allylsulphide content of onion bulb were recorded. The effects of herbicides on soil microflora and their residual toxicity on succeeding crops of okra, radish and bitter gourd was also studied.

Herbicide metribuzin at 1.0, 0.5 and 0.25 kg (a. i.)/ha (pre-emergence) proved phytotoxic for the crop. At concentration 1.0 kg (a. i.)/ha, it killed all the plants in all the replications within 20-25 days after transplanting and at lower doses of 0.5 and 0.25 kg (a. i.)/ha, it drastically reduced the crop plant population. When tried as post-emergence spray @ 0.5 kg (a. i.)/ha, it proved as contact poison, burnt the onion leaves causing death of the onion plants and resulted in their chlorosis which recovered latter on. All rates and methods of application of this herbicide proved non-selective for onion crop. Combination of pre-emergence terbutryne at 0.75 kg (a. i.)/ha + nitrofen at 1.25 kg (a. i.)/ha (post-emergence) and pre-emergence terbutryne at 0.50 kg (a. i.)/ha + post-emergence nitrofen at 1.25 kg (a. i.)/ha also resulted in phytotoxic effects on the crop. In this combination pre-emergence terbutryne was observed toxic to the crop plants. All these treatments reduced the height of plants, size of onion bulb, average weight of bulbs and yield q/ha over control weeded.

The herbicides which were not phytotoxic and proved very selective for the growth of the onion plants include post-emergence oxadiazon at 1.0 kg (a. i.)/ha, post-emergence methabenzthiazuron at 2.0 kg (a. i.)/ha, combination of pre-emergence methabenzthiazuron at 2.0 kg (a. i.)/ha + post-emergence nitrofen at 1.25 kg (a. i.)/ha, pre-emergence methabenzthiazuron at 1.0 kg (a. i.)/ha + post-emergence nitrofen at (1.25 kg (a. i.)/ha, pre-emergence nitrofen at 1.25 kg (a. i.)/ha + post-emergence nitrofen at 1.25 kg (a. i.)/ha and soil incorporation of fluchloralin @ 1.20 kg. (a. i.)/ha.

All the herbicides and their combinations significantly reduced weed intensity, fresh and dry weight of weeds over control unweeded. The poorest weed control efficiency (19.80% and 21.74%) was observed under the treatments pre-emergence metribuzin at lower doses (0.5 and 0.25 kg (a. i.)/ha) and the highest (71.87%) under treatments post-emergence oxadiazon at 1.0 kg (a. i.)/ha followed by post-emergence methabenzthiazuron (71.79%) at 2.0 kg (a. i.)/ha. None of the

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herbicide and their combination could control *Cyperus rotundus* and *Cynodon dactylon*.

Seventeen weed species were identified in onion field, the predominant were—*Gnaphallium leuto-album, Chenopodium album, Mililotus indica, Mililotus alba, Ageratum conyzoid, Portulaca oleracea, Anagallis arvensis* and *Solanum nigrum* among dicots and *Cyperus rotundus* among monocots. Amongst these weed species, *Chenopodium album, Mililotus alba* and *Mililotus indica* appear to be the real competitors.

The treatments which lowered the plant stand also lowered the yield of onion bulbs. Post-emergence oxadiazon at 1.0 kg (a. i.)/ha recorded the highest yield of onion bulbs (273.74 q/ha) amongst various treatments. The 'weed competition index' showed that the yield increase over control weeded was 23.04 percent. The next in order of highest yield were the treatments—post-emergence methabenzthiazuron at 2.0 kg (a. i.)/ha (270.71 q/ha), pre-emergence methabenzthiazuron at 1.0 kg (a. i.)/ha+post-emergence nitrofen at 1.25 kg (a. i.)/ha (262.63 q/ha), pre-emergence methabenzthiazuron at 2.0 kg (a. i.)/ha+post-emergence nitrofen at 1.25 kg (a. i.)/ha (269.00 q/ha), pre-emergence nitrofen at 1.25 kg (a. i.)/ha+post-emergenence nitrofen at 1.25 kg (a. i.)/ha (261.06 q/ha) and soil incorporation of fluchloralin at 1.20 kg (a. i.)/ha (250.69 q/ha). These treatments significantly increased the size of the bulb, weight of the bulb and recorded highest number of 'A' and 'B' grades of bulb and lowest number of 'C' grade bulb over control unweeded.

Treatments, pre-emergence metribuzin at 0.5 and 0.25 kg (a. i.)/ha, postemergence metribuzin at 0.5 kg (a. i.)/ha, pre-emergence terbutryne at 0.75 kg (a. i.)/ha+post-emergence nitrofen at 1.25 kg (a. i.)/ha and pre-emergence terbutryne at 0.50 kg (a. i.)/ha+post-emergance nitrofen at 1.25 kg (a. i.)/ha and control unweeded recorded negative weed index due to their phytotoxic effects on the crop or both due to weed competition and phytotoxic effects. The minimum negative weed index (86.96%, 78.65%) was observed in pre-emergence metribuzin at 0.50 and 0.25 kg (a. i.)/ha, respectively followed by control unweeded (65.85%).

There were no significant effects of the herbicides or their combination on the dry matter, total carbohydrates, total soluble solids, ascorbic acid and allylsulphide content of onion. None of

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the herbicides showed any harmful effects on the soil microflora-bacteria, actinomycetes and fungi. The residual studies carried out on the test crops of okra, bitter gourd and radish showed that the germination count and yield/plant of the crops sown were at par with the controls. It can be concluded that these herbicides can beused for weed control in onion crop without any danger of impairing the quality characteristics of onion bulb, without any threat to harm microorganisms equilibrium in the soil and without any deleterious effects on the succeeding crops.

The profit and loss economics calculated for various treatments revealed that for the most profitable returns, the following herbicides can be used in order of merit for weed control in transplanted onion.

1. Post-emergence oxadiazon at the rate of 1.0 kg (a. i.)/ha.
2. Post-emergence methabenzthiazuron at the rate of 2.0 kg (a. i.)/ha.
3. Pre-emergence methabenzthiazuron at 1.0 kg (a. i.)/ha + post-emergence nitrofen at 1.25 kg (a. i.)/ha.
4. Pre-emergence nitrofen at 1.25 kg (a. i.)/ha + postemergence nitrofen at 1.25 kg (a. i.)/ha.
5. Soil incorporation of fluchloralin at the rate of 1.20 kg (a.i.)/ha.

According to the availability, any of the herbicides/their combinations may be used under the agro-climatic conditions of Varanasi for higher remunerative returns over the generally adopted commercial practices.

HETEROSIS AND COMBINING ABILITY STUDIES OF DIALLEL CROSSES IN BRINJAL *(Solanum melongena* L*)*

Narayan Das *Sup. : Dr. A. N. Maurya*

In self pollinated crops, improvement in the past was based on selection in locally adopted and hybrid populations. During recent years, exploitation of hybrid vigour and Selection of parents on the basis of combining ability have opened a new line of approach in crop improvement. This approach has practical utility in breeding programmes aimed at genetic improvement of yield *per se*.

The present investigation was undertaken to study the nature and magnitude of gene effects, combining ability, heterosis, corre-

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lation coefficient and path, heritability and genetic advance for eight characters, namely, plant height, number of branches, days to flowering, number of flowers per cluster, fruit length, fruit girth, number of fruits per plant and yield per plant. Eight parents, viz., Local Oblong Purple (LOP), Green Round Local (GRL), Local Round Purple (LRP), Balck Long (BL), Pusa Kranti (PK), Kalyanpur Type-2 (T_2), Pusa Purple Long (PPL), Long White Cluster (LWC), were used in the present study.

The experiment was carried out in the experimental field of Horticulture Department, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during 1980-1982. In this study the diallel analysis was undertaken with eight parents, 28 F_1 hybrids and 28 F_2 crosses excluding reciprocals. The experiment was laid out in Randomized Block Design with 3 replications.

The experimental material was managed to maturity effecting recommended agronomic practices for the crop and biometrical observations recorded at suitable physiological maturity.

The analysis of the components of genetic variance revealed that the additive component (D) was significant for most of characters in F_1s and F_2s, except plant height, number of branches, fruit length, fruit girth, number of fruits per plant and yield per plant in F_1s and plant height, number of branches and number of fruits per plant in F_2s.

The non-additive components (H_1 and H_2) were found to be highly significant for all the characters among the progenies. The estimates of h^2 were positive and significant for most of the characters, except days to flowering in F_1s,indicatign the direction of dominance was positive. However, in F_2s the estimates of h^2 was positive and significant for most of the characters except fruit girth and number of fruits. But for the number of fruits h^2 was negative. By F components it was observed for number of flowers per cluster an excess of positive genes were responsible for controlling the character. Similarly, an excess of negative genes were controlling the character, viz., plant height, number of branches, fruit length and fruit girth in F_1 and plant height and fruit length in F_2. The estimates of degree of dominance $(H_1/D)^{\frac{1}{2}}$ were higher for all the characters in both progenies.

The magnitude of additive genetic component was higher than the non-additive component for all the characters except number

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of branches in F_1. It is clear from $H_2/4H_1$ that symmetrical distribution of positive and negative homozygotes among the parent for all the characters, except the number of flowers per cluster. From the ratio $(4DH_1)^{\frac{1}{2}} + F/(4DH_1)^{\frac{1}{2}} - F$, it was known that for the character, plant height, number of branches, fruit length, fruit girth, in F_1 and fruit length in F_2 showed equal proportion of dominant and recessive genes in the parents. The ratio h^2/H_2 denotes 6 genes for plant height and number of branches, whereas one gene for days to flowering 2 genes for yield per plant, 3 genes for number of flowers per cluster, for fruit length and girth two genes for each, 3 genes for number of fruits per plant, were responsible for the respective characters. The graphic analysis suggested the overdominance for all the characters in both F_1 and F_2 populations, except fruit length and fruit girth.

The combining ability analyses indicated that the GCA variances were significant for most of the characters, except number of branches. But in F_2 all the characters were significant. The SCA variances were highly significant for all the characters. As suggested by GCA/SCA ratio, the magnitude of additive genetic variance (GCA variance) was much higher than those of non-additive genetic variance (SCA variance) for all the 5 characters except plant height, number of branches and yield per plant.

From the different analyses, graphic component and combining ability, it is concluded that both additive and non-additive genetic variances are important in controlling yield and yield contributing characters in brinjal. The relative magnitudes of the two components varied from character to character. Complex character like yield exhibited greater proportion of non-additive gene effects as compared to the simple characters like plant height, number of branches.

GCA effects were positively associated with *per se* performance of the parents for most of the characters studied. Kalyanpur Type-2 was the best general combiner for plant height; Pusa Kranti, Pusa Purple Long and Long White Cluster for number of branches; Local Oblong Purple, Green Round Local, Black Long and Kalyanpur Type-2 for days to flowering; Local Oblong Purple, Local Round Purple and Pusa Purple Long for number of flowers per cluster; Kalyanpur Type-2, Pusa Purple Long and Long White Cluster for fruit length; Green Round L cal, Round Purple and Black Long for fruit girth; Pusa Kranti, Pusa

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Purple Long, Local Round Purple and Black Long for number of fruits/plant; Local Round Purple, Black Long, Pusa Kranti, Kalyanpur Type-2, Pusa Purple Long for yield per plant exhibited the highest GCA effects.

The estimates of SCA effects, in general, were lower in F_2 than F_1. Most of the crosses showing positive SCA effects involved one good and one poor, or even negative, general combiner, relatively higher estimates of SCA effects were usually recorded in those crosses which involved parents of distant origin.

The SCA effects were exhibited in the prosses Black Long x Pusa Purple Long and for different characters. Green Round Local x Pusa Purple Long for plant height; Local Oblong Purple x Long White Cluster and Green Round Local x Kalyanpur Type-2 for number of branches; Pusa Purple Long, Long White Cluster and Kalyanpur Type-2 x Pusa Purple Long for days to flowering (earliness); Black Long x Kalyanpur Type-2 and Local Oblong Purple x Green Round Local for number of flowers per cluster; Green Round Local x Kalyanpur Type-2 and Pusa Purple Long x Long White Cluster for fruit length; Green Round Local x Pusa Purple Long and Local Round Purple x Kalyanpur Type-2 for fruit girth; Local Round Purple x Kalyanpur Type-2 and Local Round Purple x Black Long for number of fruits per plant; Local Oblong Purple x Green Round Local and Black Long x Pusa Kranti for yield per plant.

Heterosis was estimated over the better parent (Superdominance) and over the mid-parent. Heterosis over better parent ranged from 31.98 per cent to 77.32 per cent for plant height and maximum heterosis was observed in Black Long x Pusa Purple Long.

Similarly, it ranged from 58.99 to 138.36 per cent maximum in Green Round Local x Kalyanpur Type-2 for number of branches, for days to flowering the range was-2.77 to 13.27 per cent and maximum heterosis was found on Pusa Purple Long x Long White Cluster.

Maximum heterosis for number of flowers per cluster was noticed in Local Oblong Purple x Green Round Local and range was 5.36 to 99.34 per cent. For fruit length maximum value was found in Local Round Purple x Kalyanpur Type-2 with the range 2.61 to 58.78 per cent, while for fruit girth Local Round Purple x Kalyanpur Type-2. For fruit girth the range of heterosis was 8.78 to 97.79 per cent and the maximum value was found in Local Round Purple x Kalyanpur Type-2. In the case of number of fruits the heterosis ranged

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from 9.63 per cent to 55.80 per cent and maximum in Local Round Purple x Kalyanpur Type-2.

On the consideration for yield the maximum heterosis was found in Local Oblong Purple × Green Round Local. Among all characters hybrids showed inbreeding depression.

Phenotypic and genotypic correlation coefficients were worked out among the 8 characters in F_1 and F_2 population. In F_1 progeny plant height was significantly correlated with all the characters, except days to flowering. Number of branches were correlated with number of flowers per cluster, fruit length, number of fruits per plant and yield per plant at both levels. Number of flowers per cluster and number of fruits/plant had positive association with yield at both levels.

In the F_2 population plant height had positive significant association with number of branches, number of flowers/cluster, fruit length, number of fruits/plant and yield per plant at both levels, except with fruit length at genotypic level.

Number of branches were positively correlated with number of flowers per cluster, fruit length, number of fruits/plant and yield/plant at both the levels. Number of flowers/cluster had significant positive association with number of fruits and yield/plant at both the levels. Fruit length was significantly and positively correlated with yield at both levels. But fruit girth had some effect with number of fruits/plant only at genotypic level. Number of fruit/plant had significant positive correlation with yield at genotypic and phenotypic levels.

All other component characters had positive direct effects on yield. The number of flowers per cluster had the highest direct effect followed by branches, number of fruits per plant, fruit length, days to flowering and fruit girth. The indirect effects via height in case of of all the component characters was negative including days to flowering which also had negative indirect effect via number of fruits per plant. The indirect effects via component characters in all other cases were positive contributing significantly to total genotypic confinements.

Estimates of heritability and genetic advance were obtained for all the characters. The heritability value in broad sense in F_1, the number of flowers per cluster at par with length and girth of fruits. In case of F_2, number of flowers per cluster was at par with length

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of fruits only and followed by fruit girth, yield per plant and number of fruits/plant, days to flowering, plant height and number of branches.

From the heritability (narrow sense) values it revealed that the number of flowers per cluster had highest value in F_1 and F_2 progenies.

The highest genetic advance was recorded for fruit girth in F_1 and F_2 generations.

Based on these results, certain suggestions are made to plan efficient and effective breeding plans for improving yielding potential of brinjal :

(i) Diverse parents should be selected on the basis of their *per se* performance and combining ability,

(ii) The selects from the segregating generations should be intermated in the early generations for exploiting both the additive and non-additive gene effects,

(iii) Selection should be practised on the basis of the respective weights of the different component characters for avoiding genetic slipage,

(iv) The *elite* populations should be tested over environments for judging their adaptability and ultimately for delineating the areas in which the strain is to be grown.

(v) Hybrid brinjal may be developed by producing locally adapted lones and *elite* restorers having high specific combining ability.

Seeds for F_1 hybrids in brinjal are available commercially in Japan, U. S. A. and other countries. Therefore, it is feasible to adopt heterosis breeding in brinjal.

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MYCOLOGY AND PLANT PATHOLOGY

STUDIES ON SOME ROOT DISEASES OF CAULIFLOWER (*Brassica oleracea* var. *botrytis* L.)

Yogi Raj Sharma *Sup. : Dr. K. C. Basuchaudhary*

Cauliflower (*Brassica oleracea* var *botrytis* L.) is an important winter vegetable in India. It is cultivated in all parts of country and requires heavy fertlization. Like other crops it also suffers from several diseases.

Cauliflower was found suffering heavily from two diseases wilt (*Rhizoctonia solani*) and root rot (*Rhizoctonia bataticola*). Keeping in view the importance of the crop and potentiality of the pathogens in causing loss, survey was conducted in 11 villages in Jummu Province of J & K state and 4 villages in Varanasi District (U. P.). In Jammu Province the disease intensity varied from 5.2 to 22.0 per cent in 1979 and from 5.5 to 14.3 per cent in 1980; whereas it was 7.2 to 15.0 and 8.50 to 1425 per cent in Varanasi.

The fungi, responsible for these diseases were identified as *Rhizoctonia solani* Kuhn (IMI 248574) and *Rhizoctonia bataticola* (Taub.) Butler (*Macrophomina phaseolina* (Tassi.) Goid. (IMI 242697). Infected plants could easily be identified having dull green to pale drooping leaves, complete loss of root system and plants died pre maturely. Plants infected with *R. bataticola* were characterized by poor and stunted growth, small dull green to pale green leaves initially attached to the plants. In some cases wilting was also observed.

Twelve isolates of *R. solani* varied in their amount of growth, sclerotial size, but proved equally pathogenic. *R. bataticola* colony on PDA was carbonaceous black to jet black, sclerotia smooth, black, round, on an average measured 72.61 x 72.22 um. Fungus produced pycnidial stage in nature on cowpea. *R. bataticola* was placed in group "C" of Haigh's classification (1930).

Studies on host range were carried out with 19 crops. Both the pathogens showed variations in their pathogenicity. *R. solani* proved non-pathogenic to maize, pearl millet, sorghum and egg plant,

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whereas *R. bataticola* was non-pathogenic to rice, chickpea, carrot and radish. To minimise inoculum build up and subsequent losses by these two pathogens rotation of cauliflower with non-susceptible crops has been emphasized.

In vitro production of enzymes was studied using Cup Plate Method (Dingle *et al.*, 1953). Both *R. solani* and *R. bataticola* produced cellulose, polygalacturonase pectinmethylestrase and protease but in varying ratios. Rise in pH was noticed and have no direct effect on enzyme production. Similarly, production of toxins *in vitro* by these two pathogens was also studied. Both produced thermostable, translocatable toxic substances which caused wilting in young cauliflower seedlings. Increase in time of seedling of cauliflower seeds in culture filtrate reduced seed germination and radicle length. Amount of growth had no effect on toxin production ($r = -0.033$).

Fourteen fungicides, both systemic and non-systemic, were tested in laboratory for their efficacy using poisoned food technique (Schmitz, 1930). Mercurials and Demosan proved highly inhibitory followed by systemics. Increase in concentration increased inhibition percentage, but on the whole systemic fungicides were found better.

Three systemic fungicides namely Bavistin, Benlate and Demosan, found effective in *in vitro* were tried as seed treatment at 0.1 and 0.2% concentration (w/w) in pot culture. All the three fungicides increased germination and protected cauliflower seedlings at least upto one month. The higher concentration (0.2%) was found superior. Seed treatment before nursery sowing with any one of the three fungicide is being recommended.

Effect of chemical fertilizers on disease development due to *R. solani* and *R. bataticola* was studied. Nitrogenous (urea), phosphatic (SSP) and potassic (MOP) fertilizers at different levels both individually and in various combinations were tried. Individually and in combination nitrogen with increased levels increased seedling mortality whereas phosphorus and potash reduced it. A combination of $N_2P_2K_2$ (medium levels) proved quite effective and reduced seedling mortality significantly when compared to control. Avoiding excessive use of nitrogen and application of balanced fertilizer (120 kg N, 80 kg P and 40 kg K per hectare) is being emphasized. Soils which are rich in nitrogen application of phosphorus and potash is being suggested.

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Twenty five cultivars/lines of cauliflower (20 received from IARI Regional Research Station Katrain, H. P.) were screened in pots artificially infested with *R. solani* and *R. bataticola* separately. None of the cultivar/line showed any resistance against *R. solani* while only one line Sel 5 × E. C. 103576 showed resistance against *R. bataticola*.

From the study conducted it was concluded that cauliflower suffered and suffers heavily due to *R. solani* and *R. bataticola* attack. Seed treatment with systemic fungicides (Bavistin/Benlate or Demosan), inclusion of non-susceptible crop like maize, lady's finger or egg plant in rotation, application of balanced fertilizers to the crop might provide solution to the problem.

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PLANT PHYSIOLOGY

STUDIES ON THE PHYSIOLOGICAL EFFECTS OF ATRAZINE ON MAIZE AND ASSOCIATED WEEDS

D. V. Subba Rao *Sup. : Dr. O. K. Garg*

Chemical weed control is a miracle of our technological age. Long known as one of the most arduous of agricultural operations, weed killing has taken an entirely new aspect as chemical after chemical is added to our arsenal of herbicides. And with new and better compounds being synthesized and developed almost each day, it seems that the improvements will continue for the foreseeable future.

In 1952, the J. R. Geigy S. A., Basle, Switzerland, started investigations with triazine derivatives as potential herbicides. Subsequently, numerous chemicals, like atrazine, chlorazine, propazine, simazine, trietazine etc., belonging to triazine group were synthesized and screened for their herbicidal properties. They have been used selectively in certain crops as well as for non-selective weed control on industrial sites (Ashton and Crafts, 1973).

Several excellent reviews have been written on various aspects of the triazine herbicides, i. e., history (Knusli, 1970), uses (Gast, 1970), degradation (Knusli *et al.*, 1969), molecular structure-function (Gysin, 1960, 1971), comprehensive (Gysin and Knusli, 1960) and mode of action (Ashton, 1965). In the recent years, among the triazine herbicides, atrazine is being extensively used for weed control in maize crop. Atrazine is more soluble in water and hence is less dependent on soil moisture for effective weed control. It is being extensively used for the control of unwanted vegetation in maize (*Zea mays* L.) crop as it controls all annual weeds and grasses at higher concentrations and this crop has a high tolerance for atrazine. In otherwords, weeds including grasses growing in association with the maize crop are susceptible to atrazine; whereas the corn plants are resistant to this weedicide. This selective nature of atrazine on different plant species may be utilized to control weeds on the maize field.

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Although atrazine has been popular towards controlling weeds in maize crop, its mode of action is not well understood. Stray evidences are there which indicate that atrazine inhibits the Hill reaction in the photosynthetic mechanism. However, it should not be considered the only inhibitory effects of atrazine on plants. For a clear understanding of the mode of action of a herbicide, like atrazine, its effects on other physiological activities of the plants from germination to maturity of the crop as well as the weed plants should be extensively studied.

In view of the significance of maize in our country's crop production, the obnoxious nature of perennial weeds like *Cyperus rotundus* L. (nutsedge) and *Cynodon dactylon* Pers. (bermuda grass) and scope of controlling these unwanted vegetation and to throw some light on other physiological aspects of atrazine on plants, the present investigation was undertaken at the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during the years 1975 to 1978. The whole investigation was projected in the form of three experiments as follow :

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Experiment I

Effect of atrazine on the germination behaviour of maize (*Zea mays* L.) and perennial weeds like nutsedge (*Cyperus rotundus* L.) and bermuda grass (*Cynodon dactylon* Pers.)

A pot-culture experiment was designed in February, 1976 to examine the effect of pre-emergence application of atrazine on the germination of maize seeds and sprouting behaviour of *Cyperus rotundus* L. and *Cynodon dactylon* Pers. Cemented pots, containing weed infested farm soil were allotted for studying of sprouting of weeds; whereas weed free soil was taken for germination studies of maize seeds. The pots were duly prepared and subsequently seeds of maize (*Zea mays* L. var. Ganga Safed-2 were sown. The experiment was conducted in a randomised block design with five treatments, replicated five times. The treatments included pre-emergence application of afrazine @ 1, 2, 3 and 4 kg/ha and untreated control was also maintained to compare the treatment effect. Subsequently, germination counts of maize seeds were recorded at 4, 6, 8, 10 and 12 days after sowing: whereas sprouting counts of weeds were maintained at 5, 10, 15, 20 and 25 days after atrazine application. The data collected were duly computed for statistical analysis (up to C. D. between treatments)

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to test the significance of the result. Some of the important conclusions deduced are as follows :

The untreated maize seeds and weeds did not sprout identically. This may be reasonable because plant species differ widely in their morphological make-ups and biochemical constitution in relation to their absorption of water and subsequent physiological activities during their early growth.

The effect of atrazine on the germination of maize seeds and sprouting of the two species of weeds were not the same. There is a close relationship between the chemical constitution of a compound and biochemical composition of plant tissues.

Atrazine was positively inhibitory to the sprouting of *Cyperus rotundus* L. and *Cynodon dactylon* Pers. This weedicide is a soil acting pre-emergence herbicide and, therefore, it is likely that after its entry into the susceptible plant tissues, it caused set-backs in the mobilization of food reserves. It may be related with the possible blockage of mitosis which ceased cell division and checked the sprouting behaviour.

Higher concentrations of atrazine were more and more toxic to the weeds as compared to the lower concentrations. This may be correlated with a serious disturbances in the normal metabolism of the plants.

Atrazine up to an optimum concentration (@ 2 kg/ha) stimulated the germination of maize seeds. It may be attributed to rapid degradation of atrazine to non-toxic form in resistant species of higher plants.

Higher concentrations of atrazine indicated a reduction in germination of maize seeds. It is likely that excess atrazine could not be readily degraded to non-toxic form and its residual effects affected the germination behaviour.

The findings of this experiment suggest that due to selective effects of atrazine on the germination of maize and sprouting of weeds, it can be profitably utilized to check the growth of the weed during the early growth of the maize crop.

Experiment II

Effect of atrazine in controlling nutsedge (*Cyperus rotundus* L.) and bermuda grass (*Cynodon dactylon* Pers.) and their influence on the growth and yield of maize (*Zea mays* L.)

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This part of the investigation was aimed to examine the efficiency of atrazine in controlling the weeds with special reference to *Cyperus rotundus* L. and *Cynodon dactylon* Pers., and their consequent influence on the growth and yield of maize. This experiment was initially conducted in pot-cultures during February to May and later it was repeated as a field experiment during August to November 1976. In both the cases, the experiments were laid out in a randomised block design with six treatments and four replications. The treatments included atrazine application @ 1, 2, 3 and 4 kg/ha. Besides these, hand weeding treatment and untreated control lots were also maintained to compare the weedicide effects. In hand weeding treatment, complete eradication of weeds by hand pulling was done at four growth stages i. e., 20, 40, 60 and 80 days after sowing. The maize plants were allowed to grow as such and subsequently growth records were maintained at different stages i. e., 20, 40, 60, 80 and 100 days affer sowing of the crop. Dry weight determinations of plant parts were also done at different growth stages. When the plants were matured, observations for yield and yield attributes were made. The data collected were subjected to statistical analysis to compute critical difference between the treatment effects. Some of the salient findings are summarized hereunder :

Atrazine is competent enough to remove the weeds, both of grassy nature or those belonging to the dicot group from the maize fields. The higher the concentration of atrazine, the more the weed population is reduced.

The herbicidal effects of atrazine may be related with set backs in the basic metabolism of the weed species which significantly affected their growth. It is likely that atrazine caused a disturbance in the photosynthetic mechanism of the susceptible plants.

Atrazine at subtoxic level was stimulatory to the growth of maize plants. This may be correlated with the resistant nature of the crop and the molecular structure of atrazine. It is likely that atrazine, soonafter its entry into the plants, is converted to a non-toxic form by an active catalytic compound namely benzoxazinone, which might be responsible, for developing resistance in maize plants to this herbicide. It is also possible that low concentrations of atrazine in relation to biochemical composition of resistant plant species might have stimulated some metabolic events leading to better growth and yield of the crop.

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Removal of weeds from the maize fields provided greater opportunity to the crop to absorb more moisture and nutrients from the soil. This resulted in improved growth of the maize plants and thereby elevated its yield potentiality.

Experiment III

Uptake of certain soil nutrients by *Cyperus rotundus* L. and *Cynodon dactylon* Pers. and its relation to growth and nutritional status of maize following pre-emergence treatments with atrazine.

With a view to understand the physiological effects of atrazine on the growth of weed *(Cyperus rotundus* L. and *Cynodon dactylon* Pers.*)* as well as the maize crop, this part of the investigation was projected to examine the extent of uptake of different mineral nutrients by the weedicide treated plants. The experiment was initially conducted in pot-cultures during the months of February to May 1977 and subsequently repeated in the same year during the months, July to November. In both types of experimentation, randomised block design was adopted with six treatments and four replications. The treatments included pre-emergence application of atrazine @ 1, 2, 3 and 4 kg/ha. Besides these, a hand weeding treatment and a untreated control lot were also maintained. In case of hand weeding, complete eradication of the weed was done at regular intervals (at 20, 40, 60 and 80 days after sowing). Subsequently, observations on growth attributes were made. When the crop plants started flowering, observations on time required for tasselling, silking and maturity were also recorded. Determinations for various mineral nutrients like total N, P, K, Ca, Mg and Na in the shoots of maize plants and two weeds i. e., *Cyperus rotundus* L. and *Cynodon dactylon* Pers. (20, 40, 60, 80 and 100 days after sowing) were made. Besides these, simultaneous determination for total acid hydrolysable carbohydrates in the maize shoots was also done. Some of the important conclusions merit a re-mention as follows:

Removal of weeds (hand weeding treatment) showed gradual depletion in the uptake of nutrients by the newly developed weeds after hand weeding. It provided more nutrients in the shoots of the associated maize crop.

A considerable decrease in the uptake of various nutrients in weeds was noticed with atrazine application. It may be due to active involvement of weedicide in causing morphogenetic injuries to susceptible species.

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At sub-toxic level (@2 kg/ha) there was greater uptake of mineral nutrients by the maize crop. It may be due to resistant nature of the maize plants to atrazine which may be correlated with its degradation to non-toxic compounds.

Atrazine exerted promoting effects on the growth of roots of the maize plants as observed during Experiment II. This facilitated greater uptake of nutrients through the roots and subsequently translocated to shoots.

These investigations clearly infer that atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-S-triazine) is a soil acting pre-emergence herbicide. It is selective in nature. It inhibits the growth of the most plant organs in susceptible plant species. In resistant species, it is stimulatory at sub-toxic level. The selective nature of atrazine may be correlated with its degradation after its entry into plant cells. In susceptible plant species, the chemical is not degraded and remains toxic to disturb the physiological balance of the plants at cellular level. Contrariwise in resistant plant species, it is likely to be degraded to some non-toxic form which might be stimulatory, at sub-toxic level, to the physiological activities of the plants. The inhibitory effects of atrazine act through photosynthetic mechanism and uptake of nutrients by plants. The present investigation may be considered of great significance bacause it is a step ahead towards understanding the mode of action of atrazine, as not much work has been available in the past recent years. Furthermore, the selective nature of atrazine, as reported in this investigation, may be utilized for the control of weeds in maize fields and improve crop production. The practical bearing of the results is, thus, obvious.

PHYSIOLOGICAL SIGNIFICANCE OF ZINC FERTILIZATION IN WHEAT (*Triticum aestivum* L.)

Akhouri Hemantaranjan *Sup. : Dr. O. K. Garg*

A very long history of more than twenty two hundred years exists for mineral nutrition of plants. This important discovery has been of great significance in the field of plant sciences. The revelations about the existence of mineral nutrients and their roles in plant growth have given a new direction to modern agriculture.

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The science of plant nutrition first came into light through the Greek natural philosopher, Aristotle, but the importance of mineral nutrients for the growth of plants was recognised by John Woodward in 1699. A number of macro—and micro—elements in a definite proportion play vital roles in the life processes of plants. As for instance micronutrients, required in traces or in extremely low quantity are inevitable for the growth and development of plants. For example, micronutrients like boron is essential for the translocation of sugars and zinc is important in the syntheses of the growth hormone indole-3-acetic acid (IAA), chlorophyll, nucleic acid, protein and several other enzymes, etc., as a cofactor, which ultimately result into the normal growth changes in plants.

The concept of plant nutrition has changed in the recent years. The inorganic nutrition of plants during their growth is now regarded as essentially an environmental function and it is true for the wheat plants too. The mineral requirement of plants are genetically determined and a single gene is responsible for a particular nutrient element for different plants. This means that a constant watch should be kept and extensive researches on the inorganic nutrition of each crop be taken.

Although the significance of most of the macro-elements including NPK and many other microelements have been established and commercially utilized, there are still some important micronutrients like zinc, boron, molybdenum etc., which are yet to be investigated carefully. Among these, zinc is an important microelement and of great physiological significance to plants as it is a constituent of a number of cellular proteins, enzymes, metallo-enzymes, amino acids, auxins, nucleic acids, chlorophylls, etc. Inspite of its pre-eminent position, its utilization as a fertilizer is not popular among the farmers. This has resulted into an alarming increase in the areas of zinc-deficient soils in many regions of this country. Crops like wheat in these regions very often suffer on account of zinc deficiency and their yield potentiality is considerably lowered. There are undoubtedly a number of problems like physiological explanation of zinc deficiency symptoms, nutritional requirement of a crop for this element and its relation to the stage of growth of a plant, which are yet to be worked out. And then investigations have to be carried out in relation to response of crops with special reference to newly released varieties.

Inorganic nutritional researches, with special reference to micronutrients, in India have attracted the attention of plant scientists only

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recently. Micronutrients have a great bearing on this country's agricultural programme since here exists great variations in the climatic and edaphic conditions. Furthermore, such investigations will be useful in planning a suitable fertilizer programme to improve the crop production. With these considerations and in view of the economic importance of wheat (*Triticum aestivum* L.) as an important cereal crop of this country and the world, some investigations on zinc nutrition of plants were undertaken. A resume and important conclusions of the different experiments are detailed below :

Experiment I

Zinc deficiency in relation to growth and physiology of wheat (*Triticum aestivum* L.) var. HUW–12)

A pot culture experiment was designed to assess the effect of zinc deficiency in relation to growth and physiology of wheat (*Triticum aestivum* L. var. HUW–12). Certified seeds were selected, sown and grown in carefully prepared sand culture in suitable sized cemented pots. When the plants were fifteen days old, they were divided into two lots : (i) those supplied with complete nutrient solution including zinc (+Zn) and (ii) those supplied with nutrient solution without zinc (–Zn). The nutrient solutions were supplied to plants regularly twice a week. A number of observations pertaining to visible deficiency characteristics, growth and yield characters were made. Besides these, several physiological determinations were also done to correlate the zinc deficiency effects. Some of the important conclusions drawn are as follows :

Wheat plants supplied with zinc showed a healthy and better growth and their foliage were dark green in colour with normal physiological activities. Under zinc dificiency, the plant showed a ratarded growth with the development of the interveinal areas broaden with chlorotic bands on either side of the midrib of the leaf. Consequently, the apical part of these leaves turned dry, papery and drooped. Early senescence of leaves with considerably low yields of grains were recorded in zinc deficient plants. An anatomical study of the stem and leaf clearly visualized the early disintegration of chloroplasts as well as a lack of normal differentiation of cells in the cortical regions in zinc deficient plants.

The physiological activities in Zn-deficient plants were also altered. There were reductions in indole-3-acetic acid (IAA) contents of leaves, chlorophyll 'a' and 'b' contents of leaves, nitrate reductase

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activity in leaves, catalase activity of stems and leaves and ascorbic acid content of stems and leaves. The dry matter yield, total carbohydrates (stems, leaves and grains), zinc content and uptake and total nitrogen content were found to be reduced in different plant parts in zinc deficient plants.

As regards yield characters, number of ears per plant, length of ears per plant, yield of seeds per plant and bulk weight of 1000 seeds were all reduced in-Zn plants.

The investigation explains the physiological basis of visual symptoms and profound alterations in the growth and yield of zinc deficient plants. It offers possibilities towards studying the physiological significance of zinc in plants. The use of zinc fertilizer has expanded greatly during the past twenty five years. Hopefully, our increased knowledge of zinc chemistry in soils and fertilizers will enable continued advances in this area without needless repetition of empirical approaches too often used as the research models of past.

Experiment II

Effect of various levels of zinc on the growth and yield of wheat (*Triticum aestivum* L. var. HUW-12)

In the investigation, an attempt was made to study the effects of various levels of zinc on the growth and yield of wheat (*Triticum aestivum* L. var. HUW-12). Recourse was taken to grow the plants in pots as well as in the field. Pots were filled with the soil possessing relatively less zinc (0.60 ppm). In field also, the estimated value of zinc in soil was not more than 0.60 ppm. Zinc in the form of zinc sulphate was additionally applied at five levels, i. e., 3, 6, 9, 12 and 15 ppm in pot culture experiment. The same levels were applied in the field conditions. The design of the plot was RBD (Randomised Block Design). A number of observations pertaining to growth characters and compositional changes in plant parts were made at different stages of plant growth. When the plants had matured, observations on yield were also made. Statistical analysis of the data were done and the following conclusions merit a remention :

Application of additional zinc to the soil improved the growth and yield of wheat crop. Improvement in growth and increase in yield were found to be in accordance with the increasing levels of zinc upto 12 ppm in pot as well as in the field condition. At the 15 ppm level,

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both in pot culture and field experiments, a decrease in growth and yield were recorded. The trend of growth and yield were almost the same in the pot cultures as well as in the field experiments. However, the field experiments conspicuously revealed better results over pot cultures. Maximum growth and yield were recorded at 9 ppm and 12 ppm levels. A decline in the above were recorded at 15 ppm level. It appears that toxicity of zinc for wheat begins at this and above this concentration in soil (both in field and pot experiments).

Increasing levels of zinc in pot and field conditions influenced the composition of wheat plants. There were increases in dry matter yield, IAA, chlorophyll 'a' and 'b', ascorbic acid, total nitrogen, total carbohydrates and zinc contents in plants with rising concentrations of zinc upto 12 ppm in the soil. The yield of seeds per plant was improved with the progressive rise of zinc in the soil upto 12 ppm levels too.

This proves that increasing levels of zinc upto 12 ppm provided greater availability of this element to plants and thereby improved their growth and yield.

The investigation confirms the 'physiological significance' of increasing levels of zinc in improving the growth and yield of the wheat plants especially at 9 and 12 ppm.

Experiment III

Effects of zinc fertilization on the differential response of wheat varieties *(Triticum aestivum* L.)

Importance of genetic variability in plant species cannot be disregarded in seeking its adaptibility to a specific environment. Reports are pouring in about the increasing proportion of Zn-deficiency in different states of our country. In order to recommend a variety for Zn-deficient areas, it was thought necessary to test susceptibility of some high yielding wheat varieties to zinc deficiency.

Three varieties of wheat (*Triticum aestivum* L.) viz., HUW–12, HUW–91 and Sonalika were grown in pot cultures to study their differential responses to Zn-fertilization. The pots were filled with the soil possessing relatively less zinc, i. e., 0.60 ppm only. Zinc in the form of zinc sulphate was additionally applied at two levels, i. e., 9 and 12 ppm which resulted into the rise of available zinc in the soil. Each of the treatments were replicated seven times. Their performances

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in terms of growth characters and compositional changes in plant parts were made at different stages of plant growth. When the plants had matured, observations on yield were also made. Statistical analysis of data were done and the following conclusions were drawn :

In general, irrespective of varietal differences the growth and yield of wheat crop increased progressively with progressive increase in the level of applied zinc in the soil upto 12 ppm. The behaviour of different wheat varieties was quite peculiar towards variation in levels of zinc application. In the case of the variety Sonalika, growth characters were found to be impaired under inadequate zinc nutrition. On the basis of maximum percentage increase in growth characters, dry matter yield, chlorophyll 'a' and 'b', IAA, zinc content and zinc uptake, it is inferred that variety Sonalka could be related as highly susceptible to zinc deficiency. Hence, wheat variety 'Sonalika' can be utilized as indicator plant to judge the poor zinc status of soil. Severity of sympoms was relatively less in the varieties HUW-12 and HUW-91 than those observed in the case of Sonalika. Improvement in growth and yield characters on the supplementation of zinc at 12 ppm suggests that HUW-91 could not thrive well in the absence of zinc. However, it can be said that HUW-91 has relatively greater tolerance aginst adverse conditions of restricted zinc availability than those of 'Sonalika' and 'HUW-12' varieties of wheat.

On the basis of growth characters, dry matter yield, indole–3–acetic acid (IAA), chlorophyll 'a' and 'b' zinc contents and zinc uptake, the wheat varieties can, therefore, be grouped in the decreasing order of susceptibility to zinc deficiency as follows :

Sonalika > HUW–12 > HUW–91

Hence, varieties 'Sonalika' and HUW–91 are two extremes of the yardstick for Zn-susceptibility. The former is a susceptible variety while the latter a tolerant one. 'HUW–12' keeps an intermediate position and may be considered as a susceptible variety for zinc.

In the light of the findings of the present investigation, as summarised above, it may be presumed that by virtue of the roles which zinc plays in plant metabolism, predictions can be made regarding the possible effects caused by the shortage of this element in the plants on their growth and yield capacity. Zinc deficient plants showed characteristic symptoms like the inhibition of plant growth,

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reduced leaf area and development of interveinal chlorosis of the older leaves, starting at the tips and margins. It appears that if no zinc is available to the plants, the zinc content in the plant tissues falls progressively to a very low concentration by dilution and disturbed metabolism. This shortage of zinc disturbs the synthesis of chlorophyll, IAA and proteins. The leaves turn pale-green in colour and consequently reduce the photosynthetic efficiency of plants followed by an early senescence. These changes as a result of inadequate zinc in the growing medium led to low yield of the wheat crop. Zn-deficiency also alters the carbohydrate and nitrogen status of plants. The chlorotic condition and early senescence of the leaves are themselves a visual evidence that photosynthetic mechanism and the normal process of protein synthesis are disrupted in zinc deficient condition. Furthermore, whatever reduced synthesis of carbohydrates and proteins takes place in Zn-deficient plants, their utilization is not proper and this inhibits the growth of the plants.

The physiological significance of zinc in wheat is further confirmed by the fact when the levels of zinc were increased in the soil, the growth of the plants progressively increased with a simultaneous rise in their zinc content, total nitrogen and dry matter contents, but a sharp decrease in the total nitrogen and total carbohydrates was observed in the plant parts at flowering and post-flowering stages. It may be presumed that with the greater availability of zinc, there was an increase in the protein synthesis and utilization of nitrogen and carbohydrate in plants resulting into a better development of grains.

Effect of zinc fertilization on the differential response of wheat varieties in the present investigation identifies the susceptibility of varieties Sonalika and HUW–12 for zinc especially at the levels of 9 ppm and 12 ppm. Other variety like HUW–91 may be grown by the cultivators even in the soil not sufficient with zinc since it is comparatively tolerant to such conditions.

On the basis of the conclusion, mentioned above, it may be suggested that zinc commands a great significance in maintaining a 'physiological balance' in wheat plants. The grower of this crop should, therefore, take care that this nutrient is not deficient in the soil. Better growth and yield of this important cereal crop is possible provided zinc is additionally supplied to the soil at a minimum level of 9-12 ppm (on soil weight basis), better at the initial stage of the plant growth. The practical bearing of the results of the present investigation in improving wheat production is, thus, obvious.

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STUDIES ON THE PHYSIOLOGY OF POST-HARVEST STORAGE AND CORKING DISORDERS OF APPLE IN KASHMIR VALLEY

Jagan Nath Bhat *Sup. : Dr. J. N. Singh*

The objectives of the present invesigations on two prominent apple cultivars grown in Kashmir valley were (i) to determine the effects of relatively higher concentration of calcium chloride sprays conducted late in the season and a post-harvest dip of fruits in higher concentration of calcium chloride or both coupled together on the occurrence of bitter pit (a corking disorder) in Red Delicious cv. of apple fruits (ii) to evaluate the effects of soil and foliar applications of borax in two different seasons on the mineral content of White Dotted Red cultivar of apple leaves in relation to corky core occurrence and (iii) to evaluate the effects of picking dates and varying storage conditions on the quality parameters of Red Delicious cv. of apple at different days of storage.

The investigations on the corking disorders were conducted in two orchards that had a well established history of corking disorders namely bitter pit on Red Delicious and corkey core on White Dotted cvs. of apple.

Contents of Ca, K and Mg in leaves and fruits in relation to bitter pit occurrence following calcium chloride sprays and dip treatments

With the pre-harvest sprays of calcium chloride, the contents of calcium in leaves increased while that of potash and magnesium got decreased. Thus an inverse relation between calcium with potash and magnesium was observed. This has been explained to be due to the reasons firstly total cations in plants tend to be constant and secondly potash absorption is passive and calcium inhibits the diffusion of potash or magnesium by decreasing the pore size of the membrane by binding to certain membrane components, such as phospholipids and compounds in carboxyl group.

The increase in calcium concentration or leaves due to pre-harvest sprays was sufficient enough to raise the calcium status above a critical thresh-hold limit.

The pre-harvest sprays were also found to increase the calcium content of fruits as in the case of leaves and to decrease content of potash. The content of magnesium, however, remained constant. Perhaps a decrease content of potash helped in the migration of larger

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part of magnesium to the fruit since potash is known to influence distribution of magnesium.

Fruits subjected to pre-harvest sprays coupled with dip treatment showed substantial increase in calcium because of the cumulative effect of both the treatments. Fruits that were only dipped were found to be superior to those that were subjected to only pre-harvest sprays. This was so because substantial amount of calcium entry was facilitated because of low concentration in the fruits.

Contents of fruit calcium in relation to quality parameters at different days after harvest

Fruits subjected to dip+spray and only dip treatments exhibited lesser losses in weight with subsequent days after harvest. Such fruits were also found to have a low rate of respiration probably because of a higher calcium content which inhibits respiration.

The higher fruit calcium was found to retain the ascorbic acid content and prevented its fast decline probably due to the fact that it maintains the firmness of the parenchyma on which depends the ascorbic acid synthesis.

Higher respiratory rates were found to be the result of low fruit calcium, because the presence of calcium limits the diffusion of substrate from the vacuole to the respiratory enzyme in cytoplasm and this decreases the respiratory rate, since calcium is well known to inhibit the activity of pyruvate kinase. A significant negative correlation clearly revealed that calcium played a very important role in decreasing the rate of respiration.

The fruit firmness got increased with increase in fruit calcium because calcium is always associated with structural organization of the membrane which gets stabilized due to calcium.

Late sprays of calcium chloride coupled with dip treatment of fruits produced an effective control of bitter pit. However, dipping proved superior to spraying treatments. It was therefore evident that exogenously applied calcium was incorporated directly into the cellular structure of the mature fruit. Since no pitting was observed at harvest and the pitting incresed with passage of time after harvest, it can be safely assumed that pitting in Red Delicious was basically a post-harvest problem and deficiency of calcium even at earlier stages manifested its symptoms quite late after harvest and both pitting percentage and degree of pitting increased with passage of time.

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The characteristic symptoms were observed on the calyx end. This fact has been explained to be due to calcium deficient conditions at the calyx and which accelerates respiration producing certain volatile substances which initiate cell disintegration.

Thresh-hold limit of calcium in Red Delicious apple of an average weight of 160 g ±2 were found to be 9.5 mg beyond which bitter pit was unlikely to occur.

There was no carry-over effects of pre-harvest sprays conducted in 1980 for the 1981 bearing season, probably because whatever calcium had penetrated into the leaf surfaces had either been utilized fully by the growing apples or a part of it had been immobilized by other parts of the plant other than leaves.

Mineral content of apple leaves in relation to occurrence of corky core following different methods and timing of applications of borax

Corky core of White Dotted Red cv. of apple, another corking disorder was found to be effectively controlled by resorting to both foliar as well as soil application of borax in the Fall season. Foliar application of borax in the Fall season (after harvest but before leaf fall) proved to be more effective because of more leaf canopy available for effective entry of foliar applied boron in comparison to Spring (immediately after petal fall) when the leaf area is comparatively less. Similar was the case with soil application of borax which when applied in Spring might have been subjected to leaching thereby proved less effective in comparison to Fall application.

Foliar application of boron at 70 ppm in either of the seasons proved to be the lowest effective dose that raised the boron content (about 45 ppm) in leaves and effectively controlled corky core, while in case of soil application 100 g per tree showed similar control but when applied in Fall.

A calcium-boron interaction seemed to operate in the leaves because the increases in boron content produced corresponding increases in calcium content and both were highly positively correlated with each other. An inverse relation was found to exist between boron content in leaves with nitrogen and potash contents. These findings correlated well with the fact that the orchardist who was continuously using urea in the manurial schedule in the orchard, invariably got occurrence of corky core. The inverse relation of boron

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and calcium with potash was the result of maintaining a cation balance in the leaves.

A graphic representation of the correlation between boron in leaves and corresponding corky core percentage suggested the range of 40-50 ppm for thresh-hold limit of boron in leaves beyond which no corky core was likely to occur.

Besides subsequent observations revealed that effective boron applications through either methods carried-over their effects for the next bearing season as well unlike calcium chloride sprays for the control of bitter pit. Hence boron applications need not be done every year for the control of corky core.

Effects of picking dates and conditions of storage on the quality parameters of Red Delicious cv. of apple

The main aim of the experiment was to prolong the shelf-life of Red Delicious apple by resorting to different picking dates coupled with economical conditions of storage.

Almost all the quality parameters namely pectic substances, physiological loss in weight, fruit firmness, titratable acid content, rate of respiration, sugar fractions and organo-leptic ratings were affected more by picking dates followed by conditions of storage. This was probably because of the fact that picking fruits at late fruit development stage and just before pre-climacteric peak determines the index of its senescence in subsequent days of storage.

The storage conditions viz. wax coating or wrapping in oil impregnated paper had inhibitory effects on the conversion of proto-pectin to soluble pectic substances and reduced the rate of respiration by enveloping the mini atmosphere surrounding the fruit thereby increasing CO_2 concentration and decreasing O_2.

Picking on normal dates or 10 days earlier and coating with wax or wrapping resulted in higher sugar content. Organo-leptic evaluation revealed that such fruits were acceptable to the consumers upto 60 days and all other fruits from rest of the picking dates were found to be acceptable only upto 45 days.

None of the picking dates coupled with conditions of storage made fruits acceptable to the consumers beyond 60 days.

Limits of quality parameters were arrived at which shall have to be used in its totality for evaluating the consumers acceptance but needs further investigations before its recommendation.

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SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

NITROGEN TRANSFORMATION AND MANAGEMET IN GROUNDNUT, SORGHUM AND ARHAR

Komaravolu Achuta Rao

Sup. : Dr. J. E. Shinde
Dr. B. Singh

Sorghum, groundnut and arhar are important millet, oilseed and pulse crops of India. Sorghum *(Sorghum bicolor)* is grown in about 18 million hectares mostly under non-irrigated conditions in the Peninsular States of Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Madhya Pradeh. Its production totals to 8,000,000 tons with an average yield of one ton per hectare. Groundnut *(Arachis hypogaea)* occupies an area of about 7 million hectares with a total production of 5.5 million tons and an average yield of 807 kg pods per hectare. It is usually grown in Gujarat, Andhra Pradesh and Tamil Nadu. Arhar or pigeonpea *(Cejanus cajan)* is usually grown in Uttar Pradesh, Bihar, Gujarat, Andhra Pradesh and Tamil Nadu occupying an area of 2.67 million hectares with a total production of 2,09,000 tons and average yield of 0.78 tons per hectare.

With the introduction of new high yielding varieties (such as CSH-6 for sorghum, GAUG-1 for groundnut, and Hy-2 for arhar), the use of fertilizers, particularly nitrogenous and phosphatic, has assumed a greater importance in increasing their production. These crops are usually grown under dryland rainfed conditions in soils of low to medium fertility level. Inadequate soil moisture and vagaries of monsoon often limit crop growth and make the use of fartilizers a risky proposition for the poor dryland farmers. These conditions call for improved methods of fertilization which will make the low levels of nutrient supply more efficient in crop production. In addition, the advantages from soil enrichment through legume crops in rotation should also be considered.

With this in view, seven field experiments were conducted in an Alfisol on N-fertilization of sorghum, groundnut, and arhar crops. Irrigated rather than rainfed conditions were empoloyed to ensure

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proper evaluation of the different methods of N-application and effect of crop rotation.

For the study of N transformation, a rotational experiment as detailed below was conducted for three years, during the wet seasons of 1978-1980.

	Rotation I	*Rotation II*	*Rotation III*
Wet season, 1978	Groundnut	Sorghum	Arhar
	↓	↓	↓
Wet season, 1979	Sorghum	Arhar	Groundnut
	↓	↓	↓
Wet season, 1980	Arhar	Groundnut	Sorghum

A basal application of 80 kg P_2O_5/ha in the form of single superphosphate and 40 kg N/ha in the form of ordinary urea was applied in all seasons. The latter was treated as unlabelled one. The nitrogen was applied in two doses. The plots were completely randomised for 3 types of rotations and 2 N levels and each combination was replicated six times. The control plots did not receive any nitrogen but were fertilized with superphosphate at 80 kg P_2O_5/ha level. At the centre of one replicate from each combination, a microplot of 1 sq. m. was established. The microplot was fertilized in the same manner as the bigger plot except that N-15 labelled urea of 10.121 per cent N-15 atom excess was used in place of ordinary urea. After the initial application of N-15 urea in 1978, the microplots received only ordinary urea in other seasons.

The ammonia volitilized from microplots was collected in a static traps of 1 N sulphuric acid. These traps were placed on a wooden stand at the centre of the plot and covered with plastic troughs. The cumulative loss of N was determined after pooling periodical estimations. The cumulative loss of ammonia was expressed as Kg NH_4-N/ha.

Soil samples were collected from 0-20 and 20-40 cm depth from microplots and subjected to the following analysis :

(i) Kjeldahl-N modified to include NO_3-N

(ii) KCl-extractable ($NH_4 + NO_3$)-N

(iii) HCl-hydrolyzable fractions of organic-N

(a) Ammonium-N

(b) Hexosamine-N

(c) Amino acid-N

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(iv) Pyrophosphate-soluble organic N fractions
  (a) Humin-N
  (b) Humic-N
  (c) Fulvic-N

Plant samples were taken at 3 different growth stages, dried, weighed and analysed for N. The mean yield from replicated plots and N concentration and N-15 abundance from plant samples collected from microplots were used to compute the fertilizer N uptake by crops. The data on weeds, including fertilizer N uptake, were collected only from the microplots.

For the N-management studies, a number of treatments with ordinary urea or coated urea employing different methods of application were evaluated. Coalter-urea was prepared by mixing urea with coaltar dissolved in kerosene. Coalter 1% by weight of urea was used for coating. Neemcake-urea was prepared by mixing neemcake (@ 30% by weight of urea) with coalter-urea. The experiments were conducted for 4 seasons in 1979-80. After the harvest of 1979 crop, the experimental plots were utilized to study the residual effect in the summer 1980. The yield and N uptake by the crops were estimated.

Experiments on N-management

Basal broadcast application of ordinary urea improved the yield of groundnut pods only when applied at 60 kg N/ha level. At lower levels of 30 N or 50 kg N/ha, there was neither any increase in yield nor in the uptake of N in total dry matter at harvest. Significant increase in yield was, however, obtained on basal application of coaltar-urea. Infact, coaltar-urea at 30 kg N/ha level produced an yield of groundnut pods equivalent to that obtained on basal application of ordinary urea at 60 kg N/ha rate. Various methods of application of neemcake-urea at 50 kg N/ha rate increased the average yield of groundnut pods by about 40 per cent. Band placement of ordinary urea was not as effective as band placement of neemcake combined with topdressing of ordinary urea.

In sorghum, 30 kg N/ha through ordinary urea was effective in increasing the yield only when it was split applied. The beneficial effect of split application has earlier been reported by many investigators. For basal applications, coaltar/neemcake urea was more beneficial. The coaltar-urea also increased the N uptake in grain

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more than basal application of ordinary urea. Doubling the rate of N with basal application of ordinary urea did not increase the yield more than that obtained on similar application of 30 kg N. Extra advantage from 60 kg N/ha rate was evident only with the basal application of coaltar-urea, with a yield response of about 21.2 kg grain per kg of fertilizer N. At 50 kg N level, split application of ordinary urea or band placement of coaltar/neemcake urea followed by topdressing with ordinary urea significantly increased the N uptake in total dry matter at harvest as compared to basal application of ordinary urea. The effect on yield, was, however, not significant.

In the case of arhar, at 50 kg N/ha level, the only treatments which significantly increased the grain yield were (i) band placement of ordinary urea followed by topdressing of neemcake-urea and, (ii) basal application of coaltar-urea. These two treatments gave about 22 and 20 kg grain yield response per kg of fertilizer N respectively, while for other treatments it ranged from 4.0 to 18.6 kg. Compared to basal application of ordinary urea, the N uptake in total dry matter at harvest was significantly higher also with split application of ordinary urea but there was no corresponding increase in grain yield.

Studies on residual N conducted with groundnut and sorghum crops showed that, irrespective of N sources and methods of application, no advantage was evident in both yield and total N uptake.

Two crops utilized in these experiments, viz., groundnut and arhar, were leguminous in nature and possessed the ability of symbiotic N fixation. No rhizobium cultures were added in the present study and the amount of N fixed by these crops was not determined but reported estimates under field conditions for groundnut ranged from 72 to 124 kg N/ha and that for arhar 168 to 280 kg. The outstanding feature of these estimates is their very large range over and above any variability that could be reasonably attributed to differences in method of measurement. Moreover, it is doubted whether all conditions effecting N fixation was adequately examined. It has been shown that leguminous crops derive different amounts of N from the atmosphere when the available N status of the soil varies. With so much uncertainty being associated with N fixation, it is very difficult to explain the effects of added fertilizer N. However, many published reports show that application of fertilizer N even when combined with adequate P and K generally failed to benefit the yield of groundnut and arhar, irrespective of whether or not they were inoculated with appro-

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priate strains of rhizobium. As far as ordinary methods of N applications particularly at lower rates are concerned, the present investigations generally supported the above conclusion. But it is worth noting that modified materials and/or methods of application did help in increasing the yield, at least in the absence of rhizobium culture.

The success of coated urea materials, as noted for other crops, was apparently related to either slow release of N commensurate with the crop requirement and/or to inhibition of the nitrification brought about by the associated neemcake. Both of these factors are important in minimising N losses and retaining N in the root zone for crop use. However, from practical considerations, it is important to evaluate the performance of slow-release materials singly and in combination with uncoated fertilizers in relation to methods of application in maintaining adequate nutrient concentration in root zone for optimum crop yields and N efficiency.

Rotation experiment

Experiments conducted at 40 kg N/ha rate for three years showed the mean N uptake in total dry matter of groundnut to increase significantly but not the pod yield. On the other hand, the mean sorghum yield was significantly higher on N application. The mean yield response of sorghum grain was about 27.8 kg per kg of fertilizer N. Compared to this, the mean yield response of arhar grain was only about 8 kg. Mean soil + fertilizer N uptake in total dry matter of sorghum on N application was significantly higher by about 35% over that from control plots. In arhar, however, it was not significantly different.

On application of labelled urea in 1978, the arhar crop absorbed only 4.1 kg fertilizer N per hectare as compared to about 7.8 and 10.2 kg by groundnut and sorghum, respectively. Among these crops, arhar absorbed the maximum amount of total N (136.36 kg/ha), but the feritilizer N constituted only 3 per cent of the total N. The contribution of fertilizer N in groundnut and sorghum was, however, 9.6 and 9.9 per cent, respectively. This showed that arhar utilized more soil-and/or biologically fixed N than the fertilizer N in comparison with other crops. The poor utilization of fertilizer N and low yield response in arhar may be related to its faculty of symbiotic N fixation. In addition, comparatively deeper root system and longer duration may also cause more uptake of soil N.

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The uptake of residual labelled fertilizer N in 1979 was also the lowest in arhar. As compared to about 8.8 and 8.3 per cent uptake of the fertilized N residue by sorghum and groundnut, respectively, the arhar crop absorbed only about 2.8 per cent. Low utilization of residual N, even when conditions for maximum exploitation were promoted by addition of adequate amount of unlabelled N for good plant growth, has been observed in other crops as well.

The ability of weed growth to compete with fertilizer N appeared to vary depening on the crop. Thus in 1978, the weed growth in sorghum absorbed 3.6 per cent more of labelled fertilized N than the crop itself. Similarly, the weed growth in arhar absorbed 2.3 per cent more fertilizer N. It was only in the groundnut that the crop utilized 3 per cent more fertilzer than the weeds. In subsequent years, the crop generally utilized more labelled N than the weed growth.

The recovery or fertilizer N in total dry matter of crops was the highest in the season of its application; 10.25 per cent in arhar, 19.48 per cent in groundnut, and 25.45 per cent in sorghum, or about 18.8 per cent on average of all crops. It, however tended to decrease in subsequent years. Thus, it averaged 2.76 per cent in 1979 and only 0.49 per cent in 1980. The sharp decline in the recovery of residual labelled N in succeeding crops reflects the slow rate of mineralization of immobilized N. However, as discussed earlier, arhar shows much less ability to make use of immobilized N than other crops.

A comparison of the fertilizer N recovery in 1978 calculated by both the 'N-15' and 'difference' method revealed that the latter overestimated it grossly. The overestimation by about 18 per cent in groundnut and 22 per cent in sorghum was approximately of the same order as that reported for other crops such as sudangrass, wheat and rice. But in arhar, the overestimation amounted to about 77 per cent. This unusually wide difference in recoveries by the two methods may be related to the higher amount of N removed from the soil as visualized by some investigators and possible variations symbiotic N fixation in nitrogen-treated and untreated plots. Higher recovery by the commonly used indirect 'difference' method than the 'isotopic technique' has been reported by many investigators. It has been explained that in the 'difference method' it is assumed that mineralization, immobilization and other transformations during the course of experiments are the same for both the N-treated and untreated plots. Since this assumption is usually invalid, the determination of per cent recovery by the

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'difference' method overestimated the amount of N taken up as compared to isotopic tracer method. The isotopic method not only provides a direct estimate of crop recovery but also increases the sensitivity and precision of the measurement. Because of these advantages many investigators consider the use of N-15 labelled nitrogen essential for estimating nitrogen recovery.

A balance sheet of fertilizer N drawn for the year 1978, showed that more N was left behind in the soil than what was utilized by the crop. In the case of groundnut and arhar, the fertilizer N residue in the soil exceeded the crop uptake by about 10 to 12 kg/ha. Similarly, except in the case of groundnut, the fertilizer N removed through weeding operation also exceeded the amount taken up by the crops. The loss through ammonia volatilization was about 2 kg N/ha from groundnut and sorghum plots and less than 0.5 kg N/ha from arhar plots. In Sorghum, except for a small amount of 2 kg N/ha, almost all the applied labelled N was accounted for. However, about 36 per cent N applied to arhar, and 14 per cent applied to groundnut remained unaccounted. The unaccounted N may represent the fraction lost through leaching and denitrification pathways which were not determined directly in the present investigation.

STUDIES ON SEED BACTERISZATION OF BENGAL GRAM (*Cicer arietinum* L.) WITH *Rhizobium, Azotobacter* AND *Phosphobacterin*

Bihari Ram Maurya *Sup : Dr. C. L. Sanoria*

Statistically designed field experiment employing 17 treatments was conducted with gram (*Cicer arietinum* L.) var. Type 1 in a farmer's field at Jalalpur Madan in 1978-79 and the same was repeated at the Agricultural Research Farm, Banaras Hindu University in 1979-80. In each experiment soil was plot-wise basal-dressed with 20 kg N and 50 kg P_2O_5/ha through urea and superphosphate, respectively. The cultures used as seed inoculants were *Cicer* rhizobia (BG_1 from B. H. U., Varanasi; and H_{45} from J. N. K. V. V., Jabalpur), isolates of *Azotobacter* (B_4 and B_5 from B. H. U., Varanasi) and a strain of *Pseudomonas striata* (from I. A. R.I., New Delhi). *Pseudomonas striata*, because of its ability to solubilise phosphate, has been termed here as phosphobacterin just for the sake of understanding.

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For the purpose of seed inoculation the cultures were used as (i) *Rhizobium* alone, (ii) *Rhizobium*+*Azotobacter*, (iii) *Rhizobium*+*Pseudomonas*, (iv) *Rhizobium*+*Azotobacter*+*Pseudomonas* and (v) *Rhizobium*+*Azotobacter*+extra phosphate applied to soil @ 50 kg P_2O_5/ha. Along with culture suspension sticker solution was also used to cause good adherence of the bacterial cells on the seed coats of seeds. The observations included studies on soil properties, nodulation, root and plant weights, composition of plants and nodules, crop yields, quality of straw and grain, and uptake of N, P, Ca and Mg by straw, grain and the whole crop. Each of the observed parameters of the above two experiments has been presented and discussed experiment-wise as well as in a pooled way, but all the correlations are based on only the pooled data of the two experiments. Important findings are summarised below.

Initial soil revealed homogeneity in respect of pH, EC, organic C, total N, and total P. The initial values changed at harvest and the differences were statistically analysed. Soil pH was decreased but the effect of treatments was not significant. Soil EC was significantly increased by the treatments of extra phosphate. Soil EC was increased more by *Rh.* H_{45} + *Az.* B_4/*Ps.* sp. than by *Rh.* H_{45}. Decrease in pH and increase in EC were positively correlated.

Rh. H_{45}+*Az.* B_4 gave maximum increase in soil organic C and next to this treatment was *Rh.* H_{45}+*Ps.* sp. All the culture treatments caused significant increase in soil N but the maximum value was due to *Rh.* H_{45}+*Az.* B_5+50 kg P_2O_5/ha. Variable effects of the rhizobial strains on soil N were further modified in presence of the coinoculants. Increase in soil N was positively correlated with the quality and uptake variables of grain and straw.

ODW of nodules was lowest in control and the rhizobial strains were highly effective. Treatments based on *Az.* B_5 were superior to those based on *Az.* B_4. Extra phosphate was beneficial to nodulation. ODW of nodules *Vs* gain in soil N was significant. *Rh.* H_{45} was better than *Rh.* BG_1 towards root mass. *Rh.* H_{45}+*Ps.* sp. and *Rh.* BG_1+*Az.* B_5+*Ps.* sp./50 kg P_2O_5/ha showed better effects. Treatment effect was not significant on ODW of plants but ODW of plants *Vs* ODW of nodules was significant.

Increase in nodule N was significant due to *Rh.* BG_1+*Az.* B_4/*Ps.* sp. and *Rh.* H_{45}+*Az.* B_4. Nodule P was not significant due to

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treatments on the basis of pooled data. However, in the 2nd experiment it was increased significantly by *Rh.* H_{45}+*Az.* B_4+50 kg P_2O_5/ha. Maximum increases in plant N and P were in case of *Rh.* H_{45}+*Az.* B_4+50 kg P_2O_5/ha. Some increases became obvious when rhizobial strains were used in combination with the coinoculants. In some of the combinations, rhizobial strains behaved in opposite direction.

Yields were almost the same when rhizobia were used alone or alongwith *Az.* B_4 but when they were used with *Az.* B_5 greater effects were observed. Maximum yield was due to *Rh.* H_{45}+*Az.* B_5 and next to the maximum was due to *Rh.* BG_1+*Az.*B_5+*Ps.* sp. Extra phosphate was not favourable to the yield. *Rh.* H_{45}+*Az.* B_4+50 kg P_2O_5/ha gave widest straw/grain ratio while the narrowest one was in case of *Rh.* BG_1+*Ps.* sp. Grain yield was not correlated with ODW of nodules although it showed significant correlations with straw yield and straw/grain ratio.

Significant increase in grain crude protein was due to *Rh.* H_{45} alone or its combination with *Az.* B_5 or *Ps.* sp. or *Az.* B_5+*Ps.* sp./50 kg P_2O_5/ha. Grain P was maximum due to *Rh.* H_{45}+*Az.* B_4+50 kg P_2O_5/ha. In case of grain P and crude protein, treatment combinations of *Az.* B_5 seemed superior to those of *Az.* B_4. Data on grain Mg, revealing wide variations, were nonsignificant. Grain Ca was minimum but Mg was maximum due to *Rh.* BG_1+*Az.* B_5+50 kg P_2O_5/ha.

Excepting the superiority of *Rh.* H_{45} over *Rh.* BG_1 for straw Mg, both the rhizobial strains had almost the same effect on the remaining characteristics of straw quality. However, they had variable effects in the presence of coinoculants and extra phosphate. Pooled results showed significant effect on straw P only. Straw P was more by *Rh.* BG_1+*Az.* B_4+*Ps.* sp. than *Rh.* BG_1. Compared with *Rh.* H_{45}+*Az.* B_5+50 kg P_2O_5/ha, *Rh.* BG_1+*Az.* B_5+50 kg P_2O_5/ha caused significant decrease of straw P. Straw N gave higher values in case of additional phosphate treatments and the maximum was in case of *Rh.* BG_1+*Az.* B_5+50 kg P_2O_5/ha. Amounts of Ca and Mg in straw were highest in case of *Rh.* BG_1+*Az.* B_5+*Ps.* sp. and *Rh.* H_{45}, respectively. Excepting Mg, uptake of all the nutrients by grain, straw and the whole crop was significantly affected by majority of the seed inoculation treatments over the uninoculated control. Maximum uptake of Mg by straw and of N, P, Ca and Mg by grain was in case of *Rh.* H_{45}+*Az.* B_5. *Rh.* H_{45}+*Az.* B_5+50 kg P_2O_5 caused highest uptake of N and P by straw, while Ca uptake by straw

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was highest due to *Rh.* BG_1+*Ps.* sp. From uptake point of view, *Az.* B_5 and *Ps.* sp. were better coinoculants than *Az.* B_4. Uptakes of N and P both, Ca, and Mg were maximum in case of *Rh.* H_{45}+*Az.* B_5, *Rh.* BG_1+*Az.* B_5+*Ps.* sp. and *Rh.* H_{45}+*Az.* B_5+*Ps.* sp., respectively.

Treatments involving *Rh.* H_{45} and additional phosphate gave higher values of soil N gains with no corresponding increases in the uptake of nitrogen. Uptake of N was significantly correlated with that of P and both the uptakes were correlated with the uptakes of Ca and Mg. Uptake of nutrients seemed proportionate although the uptake values depended on the quality and quantity of the produce.

Seed inoculation of *Cicer arietinum* with rhizobial strains in presence of *Az.* and/or *Ps.* sp. and extra 50 kg P_2O_5/ha, revealed better compatibility of *Az.* B_5 than *Az.* B_4 and no advantage of extra 50 kg P_2O_5/ha particularly in the above summarised experiments. Therefore, in the third experiment all the treatment combinations of *Az.* B_4 were excluded and two treatments of extra 25 kg P_2O_5/ha were included. The experimental field could be considered chemically homogeneous because the plotwise samples of initial soil revealed no significance for any of the observed soil characteristics. Excepting soil pH which showed a trend of reduction, other soil characteristics were improved significantly, at harvest. Rhizobial strains alone seemed more effective in decreasing the soil pH. Soil EC was significantly increased by *Rh.* BG_1+*Ps.* sp., *Rh.* H_{45}+*Az.* B_5+*Ps.* sp. The treatments with additional phosphate caused greater increases in EC and decreases in pH.

Rhizobium H_{45} alone and *Rh.* BG_1 alongwith the coinoculants/extra phosphate increased the soil organic C. Increase in soil N was more due to *Rh.* H_{45} than *Rh.* BG_1. *Rh.* BG_1 alongwith *Az.* B_5 and/or *Ps.* sp. and *Rh.* H_{45} in presence of *Az.* B_5+*Ps.* sp. were more effective towards gains of soil N. Extra phosphate caused greater accumulation of N in soil. Increase in total P of soil was significant due to the application of extra 50 kg P_2O_5/ha. *Rh.* H_{45}+*Az.* B_5+50 kg P_2O_5/ha gave maximum increase of organic C, total N and total P in soil. Control gave exceedingly poor nodulation while the rhizobial strains were highly effective. Combined coinoculation with *Az.* B_5+*Ps.* sp. was compatible with *Rh.* BG_1 and incompatible with *Rh.* H_{45}. Grain yield was maximum in case of *Rh.* H_{45} while the straw yield and the straw/grain ratio were maximum in case of *Rh.* H_{45}+*Az.* B_5.

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In view of the summarised experimental findings, the more pertinent conclusions are as follows :

1. Both the rhizobial strains (*Rhizobium* BG_1 and *Rhizobium* H_{45}) proved effective in all the trials.
2. When used combinedly with *Rhizobium*, *Azotobacter* B_5 was more effectrve than *Azotobacter* B_4.
3. *Azotobacter* B_5 and *Pseudomonas* sp. were individually compatible with *Rh.* H_{45}. However, as a coinoculant *Azotobacter* B_5 was more effective than *Pseudomonas* sp.
4. Combined use of *Azotobacter* B_5 + *Pseudomonas* sp. was beneficial with *Rhizobium* BG_1 and harmful with *Rhizobium* H_{45}.
5. Effect of bacterial seed inoculation depended very much on the agro-climatic conditions.
6. Looking to the effects of bacterial treatments, no specific treatment was found to influence equally all the quality attributes of the crop. However, seed inoculation in general improved the overall quality of crop.
7. Application of extra 50 kg P_2O_5/ha over the commonly used 50 kg P_2O_5/ha as basal dressing, in cases of combined inoculations with *Rhizobium* + *Azotobacter*, gave greater nodular masses with no corresponding effects on yield and quality of the crop. Therofore, application of just 50 kg P_2O_5/ha as basal dressing seems ideal in the alluvial soils of B. H. U. Research Farm.
8. Besides the crop characteristics, the soil characteristics were also influenced by the bacterial treatments. Soil fertility particularly in respect of nitrogen status was improved.
9. When the available nitrogen status of the soil was good, inoculation improved the yields, but the increases were statistically not significant. On the other hand, under such circumstances soil nitrogen was significantly improved. Therefore, use of effective strains of the inoculants in any case is not uneconomic.
10. From the point of view of recommendation, *Rhizobium* H_{45} either alone or in combination with *Azotobacter* B_5 seems more suitable for the cultivation of gram in the Indo-gangetic alluvium of Varanasi.

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STUDIES ON INTERACTION OF POTASSIUM AND ZINC IN SOME IMPORTANT PULSE CROPS

Bara Singh Badhoria *Sup. : Dr. B. Singh*

Pulses play very important role in agricultural economy of India because of their ability to fix atmospheric nitrogen and increase yield relatively well even on marginal lands under dryland conditions of low soil fertility and moisture stress. Pulses contain high protein and, therefore, serving as the cheepest source of protein for vegetarians. The area under pulses has been fluctuating between 20 and 22 million hectares in the last two decades and pulse production is stagenant around 11–12 million tonnes. The average yield being 500 kg per hectare. Stagnation in pulse production on one hand and increase in population on the other has posed serious problem of protein availability for Indian masses both in terms of quantity and quality. Pulse availability has come down from 60 g in 1951 to only 45 g in 1976 as against 104 g per capita per day as recommended by nutritionists. Eemergence of such a kind of trend is undesirable and a matter of serious concern. Import of pulses can at best be a temporary remedy of this problem. However, pulses are not in surplus in the international market as India is the primary producer of pulses in the world. Therefore, larger production and high productivity seems to be the only solution.

One of the important factors affecting the production of pulses has been lack of development of varieties which may respond to improved practices and management as the varieties of cereals do. However, a large number of varieties of different pulses are being developed under the All India Co-ordinated Pulses Improvement project which have better adaptability and give higher yield than local varieties grown by most of the farmers. There is also a need for evaluating the fertilizer requirements of these varieties for increased yield and quality grain production. Information has been piling up concerning the role of potassium and zinc in plant nutrition of cereal crops. But there is dearth of knowledge regarding their role in pulse crops. However, very few workers have demonstrated that zinc application had significant effect on the grain and straw yields of different legumes, but very little work has been reported regarding the nutrition of potassium to pulses and also its interaction with zinc on their yield and quality. The present investigation was undertaken to study the effect of potassium with and without zinc in the

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alluvial soils of Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

With a view to finding out the effect of potassium and zinc treatments on four pulse crops, e. g., black gram, green gram, chick pea and lentil, separate pot-culture experiments were conducted for two years in *kharif* and *rabi* seasons of 1979 and 1980. Treatments consisted of all possible combinations of the four levels of K (0, 15, 30 and 45 kg k/ha) as KCl, and three levels of Zn (0, 10 and 20 kg Zn/ha) as $ZnSO_4 . 7H_2O$. Each treatment was replicated three times and a basal application of P and N was given @ 10 ppm each in the form of ammonium dihydrogen phosphate and urea, respectively to 8 kg soil. Plant samplings were done at pre-flowering, pod-formation/ mid-flowering and at harvest stage. The influence of potassium and zinc and their interaction on growth attributes, nodulation, yield of the crops as well as content and uptake of these elements at different stages of plant growth and in grains was studied.

The various soil and plant analyses were done by using usual conventional methods as well as modern precision instrumental methods, e. g., spectrophotometry and flame photometry. Soil and plant zinc was estimated with DTPA and diacid mixture, respectively. The concentration of zinc in soil and plant extract were measured on a Varian Techtron atomic absorption spectrophotometer Model AA-120. The data obtained were analysed with the help of a calculator following the analysis of variance method outlined by Panse and Sukhatme (1978) to derive valid conclusions.

Potassium application significantly affected the plant growth of all the legumes studied. Significantly maximum plant growth was noted in K_1 level of potassium and further increase in the doses of potassium beyond K_1 produced declined effect and K_3 level had even negative effect over control in all the legumes excepting black gram wherein highest plant growth was found in K_3 level. Zinc application had also significant effect on plant height and the highest dose of zinc (Zn_2) gave slightly better plant growth than Zn_1 in all the crops excepting green gram where its effect was nonsignificant and maximum value was found in Zn_1 dose. The interaction of K and Zn was found significant only in black gram and chick pea. Potassium application had nonsignificant effect on root weight of green gram but increased significantly the shoot weight of green gram and chick pea. Both root and shoot weights of black gram and lentil were significantly affected

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by potassium appljcation. The highest values of both the parameters were observed in lower doses of potassium and with higher doses it gave depressive effect though remained appreciably superior over control in all the legumes. On the contrary, zinc application significantly increased the root and shoot weight of all the legumes. Significantly highest root weight was observed with Zn_1 level in all the pulses except black gram where this value was observed in Zn_2 dose. The maximum value of shoot weight have been recorded in Zn_2 in all the legumes except lentil where highest value was found in Zn_1. The interaction of K × Zn was found significant only in shoot weight of chick pea plants.

Dry matter accumulation increased with the advancement in the age of all the crops studied. Lower doses of K generally gave significantly higher values of dry matter accumulation over control and increasing doses of K subsequently resulted in depressive effect in all crops though remained superior over control excepting lentil where all the K levels in initial and in flowering stage had negative effect over control. In black gram the highest dry matter production was recorded in K_2 level while in other crops the highest value was observed with K_1 level.

Unlike the effect of potassium, increasing levels of zinc increased the dry matter yield at all the stages of crop growth in all the cases with maximum value always being with Zn_2 level excepting in lentil where the highest dry matter yield was recorded with Zn_1 level and with Z_2 it gave declined effect. The interaction of K x Zn had significant effect only at harvest stage in chick pea and at flowering and harvest stages in lentil.

Application of potassium significantly affected the grain yield of all the pulses except lentil where it had nonsignificant effect. Maximum grain yield was recorded with K_2 level in black gram and in K_1 level in rest of the legumes. Increasing levels of potassium beyond these doses in respective crops produced declined effect and so much so in lentil, the highest level had negative effect over control. On the other hand, increasing levels of zinc was accompanied by a corresponding increase in the grain yield and maximum value was obtained with Zn_2 level in all the crops excepting lentil wherein this value was obtained with lowest level of the element. The interaction effect of K x Zn was found significant only in green gram.

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Potassium application had markedly influenced the nodulation of all the grain legumes. Lower doses of the element recorded significantly highest nodule number and their dry weight in all the grain legumes except lentil. Every increase in the levels of the applied K in these crops exhibited declined effect on nodulation and in crops, viz., chick pea and green gram even negative effect over control. All the main effects of K had negative effect over control in lentil. Zinc application also significantly affected the nodule number and their dry weight in all the grain legumes. Both the levels had an edge over each other in influencing either of the parameters in these crops. However, highest dose of zinc had negative effect over control in influencing both the parameters of green gram.

Potassium content in plants and grains was relatively higher with higher levels of potassium in all the four legumes studied. The maximum K content was observed at initial stage in all the crops and minimum remained at harvest stage. However, in chick pea first dose of K produced appreciable low K content or negative effect over control at all the stages of crop growth. Unlike the effect of K treatments, the effect of zinc treatments on K content showed varied behaviour in all the legumes. The potassium content in black gram plants as well as in grains and in chick pea plants decreased with increasing levels of zinc application. However, its content was increased in accordance with the doses of zinc application at all the stages of crop growth in green gram and lentil crops.

The potassium uptake in plants increased with the advancement in the age of the crops and, therefore, cumulative uptake of K was observed at harvest stage in all the legume crops. Maximum K uptake was found in K_1 level of potassium in all the three stages of plant growth as well as in grains of green gram and chick pea crops. But in black gram this value is obtained in K_2 level. All the main effects of K had negative effect over control at initial and flowering stages of plant growth in accordance with the doses of K application in lentil. Zn application markedly increased the uptake of potassium in plants and grains of all the pulse legumes. The uptake of K increased with increasing levels of zinc both in plants as well as in grains in all the crops except in lentil where the maximum value was observed in Zn_1 level.

The zinc concentration and its uptake by all the pulse plants and grains was appreciably increased by zinc application. Zinc con-

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centration decreased with the advancement in the age of the plants in all the legumes excepting green gram in which decrease in content was obtained only at harvest. The highest uptake was observed between flowering to maturity in all legumes except in lentil where this was found at flowering stage. Increase in zinc concentration and uptake was according to the doses of zinc application at all the stages of crop growth as well as in grains of almost all the legumes. But in lentil the highest uptake value was found in Zn_1 level at initial and flowering stages of crop growth. Zinc uptake was found highest in lower doses of K application and every increase in the doses of K applied was accompanied by a corresponding decrease in the zinc uptake at all the stages of plants as well as in grains of all the legumes whereas in all cases the zinc content was increased by increasing the doses of K in the soil. However, in lentil no regular and consistent zinc uptake was observed due to K application.

Significantly highest protein content was found in K_2 level of potassium in all the crops and further increase in the dose of K beyond this level produced declined effect and so much so in green gram it had negative effect over control. Like potassium, application of zinc also increased the protein content of all the grain legumes and maximum content was found with Zn_2.

The available potassium content of the soil showed increasing trend with increasing rates of potassium in all the crops. K_3 dose of potassium gave significantly highest available K in the soil after all the crops while K_1 level had significant negative effect over control in this respect in all the legumes excepting lentil. Application of zinc had nonsignificant effect on the available K content in soil after the harvest of *kharif* crops whereas its application significantly reduced the available K content after *rabi* crops.

Available zinc content increased with increasing levels of zinc application and maximum value of available zinc was obtained with its highest level and minimum remained in control in all the cases. On the other hand, K application had nonsignificant effect on the available zinc content after *rabi* crops but increased significantly its availability after *kharif* crops with maximum value with high doses of the element in all the cases.

The results obtained in the present investigation lead to the conclusion that application of potassium @ 15 kg K/ha (K_1 dose) was

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found to be significantly superior in increasing the grain yield of all the legumes under low to medium status of potassium and further increase in the doses of applied K resulted in declined trend. However, with regard to zinc application, zinc @ 20 kg Zn/ha (Zn_2) gave highest yield but it was not significantly and proportionately superior over Zn_1 dose (10 kg Zn/ha) which gave significantly higher grain yield over control in all the grain legumes.

CHARACTERISATION OF SALT-AFFECTED SOILS OF EASTERN U.P. AND DYNAMICS OF RECLAMATION BY USING GYPSUM AND PYRITES

Anuj Pratap Singh *Sup. : Dr. Sant Singh*

The present investigation entitled "Characterisation of salt-effected soils of eastern Uttar Pradesh and dynamics of reclamation by using gypsum and pyrites", was undertaken during 1979–81 with the following objectives :

(1) To gather information on site characteristics and morphological characteristics of salt-affeced soil profiles of eastern Uttar Pradesh.

(2) To know the physico-chemical properties of salt-affected soil profiles of eastern Uttar Pradesh.

(3) To classify the salt-affected soils of eastern Uttar Pradesh.

(4) To investigate the effects of various levels and methods of gypsum and pyrite on yield of rice and wheat in representative alkali soils of eastern Uttar Pradesh.

(5) To find out the interaction effects of gypsum and pyrite on yield of rice and wheat.

(6) To find out the influence of amendments on mineral composition of grain and straw of wheat-rice crops.

(7) To find out the effect of different levels and methods of gypsum and pyrites on changes in chemical properties of alkali soils subsequent to harvesting of rice and wheat during four crop seasons.

The salt affected soils of eastern Uttar Pradesh have been developed under semi-arid to humid climate where mean annual rainfall is about 1000 mm. The salt effected soils of these areas have been rendered uncultivable due to development of alkali conditions. There

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are various factors for the formation of alkali soils, i. e., restricted drainage, high water table and the presence of *kankar* pan leading to salt accumulation on soil surface. In addition, during the summer months the salt tend to concentrate on the surface as a result of the evaporation of stagnated water.

Ten salt-affected soil profiles of eastern Uttar Pradesh with two profiles from each district of Faizabad, Sultanpur, Pratapgarh and Azamgarh, have been studied for laboratory evaluation. Results on morphological feature and chemical characteristics of the profiles have been reported. Important differentiating morphological characteristics, like colour, texture, consistency, drainage carbonate effervescence, *kankar* deposition and root penetration, have been studied for the different horizons right on the spot. From the morphological features of the soil of profiles, it was observed that the salt-affected soils of eastern Uttar Pradesh have light grey whitish to dark grey brown or pale olive in the upper horizon and pale yellow to light yellowish brown in sub-surface horizons. The texture of the upper horizon varies from sandy loam to loam and in the sub-surface horizons the texture is loam to silty loam and clay loam. The structure changes from single grained or granular to subangular blocky. The consistency was found to vary from soft or slightly hard/friable/firm and slightly sticky and plastic to very sticky and plastic and the drainage was poor. They are calcareous and carbonate effervescence was found to range from slight to strong with mottling. Two types of *kankar* nodules formation were also found within the soil profiles, firstly small piece of calcium carbonate (mustard size) which can be presumed of younger origin and, secondly, big piece of calcium carbonate (potato size) of *kankar* nodules which are of older origin. The extent of root penetration gave clear indication of the degree of compactness, pore-space as well as *kankar* deposition within the soil profiles.

The physico-chemical characteristics of the profiles showed that salt accumulation was more in the surface layers and alkalinity hazard was more in depressed land and near the canal areas. Higher pH value was found in surface layer than in the lower surface in most cases of these salt-affected soils. It ranged from 8.5 to 10.5. The electrical conductivity of the soil saturation extract ranged from 6.0 to 18.2 mmhos/cm in the surface horizons and 2.5 to 10.0 mmhos/cm in the lower surface of these profiles. The clay content was generally

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found to increase with depth and texture was lighter in the surface and heavier in the sub-surface. The calcium carbonate generally increased the sub-layers. The status of orgaaic carbon was low often being about 0.5 per cent in the lower surface in most cases.

The data on chemical composition of saturation extract reveal that all the soil profiles of eastern U. P. are dominated with the soluble sodium cations. The soluble calcium and magnesium were found in very little amount whereas soluble potassium was practically absent in all the profiles studied. Bicarbonates are the major soluble salts in all the profiles. The cation exchange capacities of the profiles were found in increasing order with the depth in some cases, but in some profiles such trends could not be seen. The exchangeable sodium percentage of the soils were high in the surface layers which decreased slightly with increasing depth.

Ten salt affected soil series of eastern Uttar Pradesh have been studied and classified as per comprehensive soil classification system (7th Approximation), 1960 of U. S. A. D., soil survey staff as given in table 21. The soils of salt affected areas of eastern Uttar Pradesh have been classified under "Aridisols" and "Alfisols". The soil series of Kumarganj, Neoridad, Tikari, Kurebhar, Deehvalyes, Mungrabad-shahpur and Chandeswar keyout to "Aridisols" by virtue of the presence of ochric epipedon and argillic diagnostic horizons or natric horizon. These soils are usually dry for most part of the year except during monsoon. They have high water table due to *kankar* pans in sub soil. Further, it is classified under two sub order on the basis of presence or absence of an argillic horizon i. e. *Argids* and orthids. Most of the season *Argids* are dry and have argillic horizon or natric horizon in which clay have accumulated by illuviation from upper horizons. They may also have durapan in sub-surface. *Orthids* are dry in most of the season and have essentially little argillic or natric horizon, but have an ochric epipedon and duripan in sub-surface. Two great groups viz. Natragid, Nadurargid have been diagnosed under the Argids and one great soil group Durorthid have been diagnosed under the orthids. Further, sub soil group have been considered on the basis of soil moisture regimes. Typic, Aquic and Ustic. Family name contains textural class fine clay, mixed calcareous and hyper-thermic temperature regime.

The remaining soil series namely Newada, Takha and Marteenganj key out to Alfisols by virtue of presence of ochric epipedon and

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Argillic diagnostic horizons. They have excess moisture to keep the moisture level at least three month in whole of year due to some localized depression and uncontrolled canal irrigation over a long period. Two sub-order have been proposed on the basis of soil moisture regime 'aquic' and 'udic' enabling placement under Aqualfs and udalfs. Sub-order Aqualfs employs wet conditions and udalfs employs for udic soil moisture regime. Two great soil group namely Natraqualifs and Natrudalfs have been diagnosed on the basis of presence or absence of natric diagnostic horizon respectively. Natraqualfs, Natraqualfs is represented by Aquic. Newada series and Aquic Takha series at the sub-group level. Newada series is a member of fine loam, mixed hyperthermic family of Aquic Natraqualfs, Takha series is a member of fine loamy mixed hyperthermic family of the Aquic Natradalfs. The great group Natradalfs is represented by the Marteenganj series which has been classified as fine loamy, mixed hyperthermic family of typic Natradalfs, as they agree with central concept of this order.

In addition to above studies, field experiments were also undertaken for two years (1978-80) in the sequence of rice and wheat crop. The treatments given were each of five levels of gypsum and pyrite viz. 0, 25, 50, 75 and 100 per cent GR and two methods (M_1 and M_2). Among the methods M_1 consist of separate mixing of amendment into the soil followed by immediate light irrigation and was also left such for a period of ten days for oxidation before transplanting and in M_2, amendments were mixed into the soil and that was immediately submerged with water.

On the basis of crop yield changes in chemical composition of plant parts, improvement in soil conditions as pH, electrical conductivity and exchangeable sodium percentage, the effectiveness of these treatments combinations were assessed.

On the basis of experimental findings it was observed that increasing levels of amendments showed clear response on increased yield of rice and wheat. Among the amendments viz, gypsum and pyrite, the gypsum was comparatively proved to be more effective on application of 100 per cent Gypsum Requirement often pyrite in M_2 method. Whereas in case of pyrite, the highest yield of both the crops were recorded at 100 per cent gypsum requirement in M_2 methods. However, it was also found that these differences were statistically not significant beyond 75 per cent GR in M_1 and M_2 methods. Similar trend was also seen in case of pyrite. In case of

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M_2 methods of pyrite, however, the differences in yield on account of doses were significant upto 100 per cent GR. Over all gypsum treated plot in all the treatments and methods gave better response than pyrite treated plot. Therefore, the response of gypsum was found to be superior than pyrite.

The application of gypsum and pyrite were found to be effective in increasing the nitrogen, phosphorus, potassium, calcium and magnesium contents in paddy and wheat grain and straw. The differences in nutrient content in M_1 and M_2 methods of gypsum and M_1 methods of pyrite application were significant upto 75 per cent GR, whereas in M_2 methods of pyrite application these differences were significant upto 100 per cent GR. Out of these two amendments gypsum was significantly superior to pyrite in regard to nutrients enhancement in the crops.

It was also found that with increasing levels of gypsum and pyrite sodium content decreased in grain and straw of both the crops. Gypsum was found to be superior to pyrite in decreasing sodium content. Gypsum was more effective in reducing the pH, E. C. and E. S. P. of the soil in comparison to pyrite in both the season.

The finding presented in the thesis clearly established the overall superiority of gypsum over pyrite in reclaiming soils of Uttar Pradesh. The pronounced effects of gypsum with M_2 method treatment was also found. Whereas pyrite showed similar effect in M_1 method.

STUDIES ON RESPONSE OF POTASSIUM AND MAGNESIUM WITH OR WITHOUT ORGANIC MANURE BY MAIZE CROP IN ALLUVIAL SOIL

Babu Lal Singh Sup. : *Dr B. Singh*

Potassium is an essential nutrient element in the life processes of plants, human beings and animals. This element is absorbed by plants in larger amounts than any other mineral elements except nitrogen. It plays an important role in soil-plant relations. Not only this element is essential to complex biochemistry of plant growth, but also its presence in the soil in adequate amounts and in suitable proportions to other nutrients is necessary if the soil is to be a suitable medium for plant root development. Potassium is essential for starch

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formation, translocation of sugars and for cell division. This element also acts as activator of many enzymes in physiological activities in plants. It increases resistance in plants against frost, pest attacks and certain plant diseases. The role of potassium in maintaining adequate water relations in plants and plant turgour are of paramount importance. Thus, it has a specific and vital role in dry farming in arid zones. The uptake of several nutrients by plants is greatly accelerated by the presence of potassium ion. It decisively influences the quantity and quality of the plant substance and its constituents.

Magnesium is vital to the production of chlorophyll because every molecule of chlorophyll contains a magnesium ion at the core of its complex structure. A part of the distributed magnesium functions in enzymes systems involved in carbohydrate and phosphate metabolism. Numerous phosphorylation reactions relating to nitrogen metabolism in plants are catalyzed by this element. Magnesium is related to the synthesis of oil, with sulphur it brings about significant increases in the oil content in several crops. The magnesium supply may be adequate to prevent deficiency symptoms shown in plants and yet be inadequate for the nutrition of animals that eat the plants. Mayland and Grunes (1974) recommended that magnesium concentration in forage should be about 0.2 per cent to avoid grass tetany in ruminants. Furthermore, grains with higher magnesium content have also been found to be important in relation to human health.

Farmyard manure is one of the most important by-products. By its utilization, part of the unused portion of the crop may enter the soil, there to exert an influence greater than its nutrient content would lead one to expect. Since manure is available in limited amounts on an average farm and as mineral fertilizers give good results on cereals and legumes, it is often considered judicious to reserve most of the manures for other crops such as; corn or cash crops as cabbage, tobacco, cotton or potatoes.

Keeping in view the prospects of maize nutrition, a field experiment was undertaken to evaluate the effect of potassium and magnesium with or without an organic manure on maize crop (Manjari composite) grown in alluvial soil of Research Farm of the Institute of Agricultural Sciences, B. H. U.

The maize seeds were sown in the field laid out in Factorial Randomized Block Design. The soil was supplied with four levels of K and three levels of Mg fertilizers and two levels of FYM. N and P were applied as per local practices. The individual and interaction effects of

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various treatment levels of K, Mg and FYM were studied on growth parameters and drymatter accumulation at different growth stages, cob length and grain yield of maize. The content and uptake of K, Mg, N, P and Ca in plants at different growth stages and in grains have also been assessed.

The various soil and plant analyses were done by using usual conventional methods as well as modern precision instrumental methods, e. g. spectrophotometry and flame photometry. The data obtained were analysed on a computer and discussed to draw valid conclusions.

The results revealed that K, Mg and FYM treatments individually produced significant differences in plant height at all the growth stages and in cob length in both the years. Maximum plant height was observed with FYM_1 application at all the growth stages while highest cob length was obtained with K_2 level in both the years. Among various treatment combinations, only K x FYM interaction was significantly effective on plant height at all the growth stages and on cob length in first year. With this significant interaction, maximum effect was observed with K_2 x FYM_1 combination. During the second year K x Mg and K x FYM interactions at the initial stage, all the interactions except K x Mg x FYM at the second stage and only K x FYM interaction at the harvest stage on plant height and K x Mg and Mg x FYM interactions on cob length were significantly effective. Among the significant interactions, K_2 x FYM_1 combination gave highest plant height at all the stages and K_2 x Mg_2 combination gave maximum cob length.

Increase in the dry matter accumulation was two times more at the second stage and three times more at the harvest stage as compared to the first stage during both the years. In both the years, highest dry matter was recorded with FYM_1 level at the first and second stages while with K_2 level at the harvest stage.

Grain yield was also highest with K_2 level in both the years. Among various interactions, only K x FYM interaction was significantly effective on dry matter yield at second and harvest stages in the first year. In the second year, K x FYM interaction at first stage and K x FYM and Mg x FPM at harvest stage were significantly effective while at second stage all the interactions were nonsignificant in this respect. On grain yield, only K x FYM interaction was significant in both the years. Among all, K_2 x FYM_1 combination induced highest dry matter and grain yield in both the years.

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K content in plants was significantly affected by K, Mg and FYM treatments individually at all the growth stages and also in grains in both the years. Maximum K content in this respect was observed with K_3 level in both the years. Increasing levels of K progressively increased the K content in plants and grains while that of Mg did not show any linear trend. FYM application definitely increased the K concentration in plants and grains in both the years. Treatment interactions, K x Mg, F x FYM and Mg x FYM were significantly effective at first and harvest stages while only K x FYM at the second stage in the first year. Among them, K_3 x FYM_1 combination induced highest K content at all the growth stages. In second year, K x FYM interaction at the first stage and K x Mg at the harvest stage was significantly effective while all the interactions were nonsignificant at the second stage. All the interactions were nonsignificant on K content in grains in both the years.

Significantly higher uptake of K was noted with K_2, Mg_1 and FYM_1 levels at all the growth stages in both the years. Of them, FYM_1 level gave highest K uptake. Uptake of K decreased with highest rate of K and Mg individually throughout the plant growth. Among all the significant interactions, $K_2 \times FYM_1$ combination was most superior for maximum K uptake by plant in both the years. Total K uptake of grains was also significantly affected by all the treatments of K, Mg and FYM in both the years. Among all, K_2 level was significantly superior for highest uptake of K. All the treatment interactions were nonsignificant in this respect.

Maximum Mg content in plants was recorded at the initial stage in both the years. All the treatments were significantly effective on Mg concentration at all the growth stages in plants as well as in grains in both the years. Highest rate of K and FYM application significantly retarded the Mg concentration in plants as well as in grains in both the years. Among all the significant interactions, $K_2 \times FYM_3$ and $K_2 \times Mg_2 \times FYM_0$ combinations in the first and the second years, respectively, induced highest Mg concentration in plants. Of them, $K_2 \times FYM_0$ combination induced highest Mg content in grain in both the years.

Total uptake of Mg by plants as well as by grains was affected similarly as its content by the individual levels of K, Mg and FYM treatments. The uptake of Mg was positively correlated with the age of the crop in both the years. Among all the significant interactions, $K_2 \times FYM_0$ and $K_2 \times Mg_2$ combinations, respectively in first and second years induced highest Mg uptake by plants. Highest Mg uptake was recorded by grains with $K_2 \times Mg_2$ in the first year and $K_2 \times FYM_0$ in the second year, among all the significant interactions.

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All the treatments of K, Mg and FYM individually were significantly effective on N concentration of plants at all the growth stages and also in grains in both the years except Mg treatment at initial stage in the first year. Among all the treatment levels, K_2 was responsible for highest N concentration at all the growth stages of plant and in grains in both the years except at harvest stage in the first year. Only $K \times FYM$ interaction on N content of plant at the second stage was significant in first year, maximum being with $K_2 \times FYM_1$ combination. Similarly, only $K \times Mg$ interaction was significant at initial stage in second year, maximum being with $K_2 \times Mg_2$ combination. N content of grains also significantly affected by only $K \times FYM$ interaction in second year, maximum being with $K_2 \times FYM_1$ combination.

There was a significant increase in N uptake by plants, at all the stages with K_2, Mg_2 and FYM_1 levels in both the years, maximum uptake being with K_2 level. Among the significant interactions, $K_2 \times FYM_1$ combination induced maximum N uptake in this respect. The N uptake by grains was also highest with $K_2 \times FYM_1$ in both the years, among all significant interactions.

P concentration was negatively correlated with the age of crop in both the years All the individual treatments, at all the growth stages of plants and also in grains were significantly effective on P concentration in both the years. K_2 level induced highest P concentration in plants as well as in grains. In all the significant interactions, $K_2 \times Mg_1$ and $K_2 \times Mg_2$ combinations at first and second stages, respectively gave highest P content in plants in first year. However, in second year, $K_2 \times Mg_1$ at the initial and second stages and $K_2 \times Mg_2$ at harvest stage gave highest plant P concentration. P content of grains was significantly affected by $K \times FYM$ interaction, maximum being with $K_2 \times FYM_1$ in the first year. No significant interaction was noted in second year in this respect.

Uptake of P by plants was significantly affected by all the treatments of K, Mg and FYM individually at all the growth stages and also by grains in both the years. K_2 level induced highest P uptake among all the treatment levels in this respect. Among the significant interactions $K_1 \times Mg_2$ combination at the initial stage and $K_2 \times FYM_1$ combination at the second stage induced highest P uptake by plants in the first year. All the interactions were nonsignificant at harvest stage. During second year, $K_2 \times FYM_1$ combination, among all the significant interactions, induced highest P uptake at all the growth stages. P uptake by grains was significantly affected by only $K \times FYM$ interaction, maximum

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being with $K_2 \times FYM_1$ combination in the first year. No interaction was significant in the second year.

Ca concentration in plants at all the growth stages and in grains was significantly depressed with increasing levels of K, Mg and FYM treatments separately. Higher Ca contant was obtained with K_0, Mg_0 and FYM_0 levels separately in both the years. Among all the significant interactions, $K_0 \times Mg_0$ combination induced highest Ca concentration in plants at initial and harvest stages and $K_0 \times FYM_0$ at harvest stage in the first year. However, during second year, $K_0 \times FYM_0$ combination at the initial and harvest stages and $K_0 \times Mg_0$ at the second stage induced highest Ca concentration. All the interactions were nonsignificant on Ca concentration of grains in both the years.

The uptake of Ca in plants and also in grains was not observed to be in any linear trend with increasing levels of K and Mg while FYM enhanced it in both the years. Uptake of Ca was positively correlated with the age of crop in both the years. Among significant interactions, Ca uptake by plants was highest with $K_1 \times Mg_0$ combination at second stage and with $K_0 \times Mg_2$ combination at harvest stage in the first year. All the interactions were nonsignificant in the first stage. During second year, among significant interactions, $K_1 \times FYM_1$, $Mg_2 \times FYM_1$ and $K_1 \times Mg_2$ combinations induced highest Ca uptake at first, second and harvest stages, respectively. The uptake of Ca by grains was significantly affected by all the treatment interactions in both the years.

Availability of K in post harvest soil was significantly affected by K, Mg and FYM treatments separately in both the years except by Mg treatment in the first year. Higher K availability was recorded with K_3, Mg_1 and FYM_1 treatment levels separately in both the years. Of $K \times FYM$ significant interaction, $K_3 \times FYM_1$ combination induced highest availability of soil K in both the years.

Availability of Mg in post harvest soil was affected similarly as K by individual treatments in both the years. Higher availability of Mg was recorded with K_0, Mg_2 and FYM_1 levels separately in both the years. Among them, highest availability was observed with K_0 and Mg_2 levels, respectively, in the first and second years. Of $K \times Mg$ significant interactions, only $K_0 \times Mg_2$ combination induced highest Mg availability of post harvest soil in both the years.

All the treatments of K, Mg and FYM individually were significantly effective also on pH of post harvest soil in both the years. pH value of soil increased with increasing levels of K while it decreased

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with increasing levels of Mg and FYM application over control in both the years. Lower pH value was observed with K_0, Mg_2 and FYM_1 levels in both the years. Among them, lowest pH value was recorded with K_0 level and FYM application, respectively in the first and the second years. All the interactions were nonsignificantly effective on pH of post harvest soil in both the years.

STUDIES ON CHARACTERISTICS OF RHIZOBIAL ISOLATES AND SUITABILITY OF CARRIERS FOR RHIZOBIAL INOCULANTS

Mridula Sexena Sup : *Dr. C. L. Sanoria*

This investigation is concerned with some important aspects of Rhizobium Production Technology. Primary requisites in the production of rhizobial inoculants are the effective strain/strains of *Rhizobium*, suitable carrier and the conditions conducive to the growth and survival of introduced rhizobia. Researches carried out towards the fulfilment of some objectives pertaining to the above stated growing field in our country were divided into three subheads and the same have been reported in earlier pages *in toto* as I, II and III chapters comprising 'Materials and Methods' and 'Results and Discussions'. Incorporating the main conclusions, the findings have been summarised below in a chapterwise sequence.

I. Identification and characterisation of rhizobial inoculants

Number of rhizobial isolates included initially for the above purpose were 15 from gram (*Cicer arietinum*), 10 from pea (*Pisum sativum*), 5 from lentil (*Lens esculenta*) and 3 from khesari (*Lathyrus sativus*). During the process of repeated plantings for the sake of purification, 15 colony variants were obtained from the main rhizobial isolates of gram. Thus the total number of cultures became 48. Gram rhizobia are very specific to gram; whereas isolates from the remaining 3 legumes are taxonomically placed under the same species of *Rhizobium*, named as *Leguminosarum*.

Nodulating ability of any *Rhizobium*, strain constitutes the confirmatory test and the same was carried out in properly sterilized pots containing farm soil. Isolates were tested for nodulation on the same host species from which they were isolated. Nodulation test was

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positive for H45I[1], H45II[2], H45J[3], BGI[3], BG3II[1], BG7I[3], BG7II[2], BG11[1], BG18[1], and BG19[3] on gram; BP2[3], BP5[3], BP6[3], BP10[2], BP11[3], and BP15[1] on pea; BL3, BL3[3], BL4[3] and BL5[2] on lentil; and BK2[3] and BK4[3] on khesari. The superscript, 1, 2 & 3, over the isolate indicates the nodulation potential i. e. poor/medium/heavy, respectively, in the soil free from the competing native rhizobia.

Generation time calculated individually for the above isolates was less than 1 hour in case of BG3II, BG11, H45J, BP5 and BP6; 1 to 2 hours in case of BG1, BG7I, BG7II, BP2, BP15, BL3, BL4, BL5 and BK4; 2 to 3 hours in case of BG18, BG19, BP10, BP11 and BK2; and more than 5 hours in case of H45I and H45II.

Morphological tests comprised determination of shape and size of cells alongwith their responses towards gram staining while the cultural tests included growth on YEMA slant, surface growth in YEM broth, and colony characterisation in congo red YEMA plates in respect of colour, shape, size, elevation, contour, margin and slime production for all the 48 cultures. The cells were invariably rod shaped with very small to medium sizes, staining negatively with gram staining. Surface growth in YEM broth being membraneous for all of them, growth on agar slant was effuse for BP2, beaded for some variants of H44 and H45, and filiform for the remaining isolates. Colonies were smooth in contour with entire margins. Colony elevation was flat for some and convex for majority of the isolates. Slime production was negative for H45J, BL5, BG16 and the beaded forms of isolates. Colonies were circular for many isolates but punctiform for BG16 and 5 variants of H45. Isolates differed in colony size ranging from about 0.2 to 1.3 cm. Colouration of colonies in congo red medium was a remarkable feature; distinct colourations with variegated patterns were observed for various isolates.

In case of nodulating isolates, physiological and biochemical tests consisted of acid production, nitrate reduction, gelatin liquification, growth in Hoffer's alkaline broth, protein and starch hydrolysis, and fermentation of glucose, sucrose, maltose, lactose and ribose. Gelatin liquification and growth in alkaline broth being negative for all, acid production was positive in varying degrees for most of them; the exceptions were BG11 and H45J (alkaline) and BG1, BP5, BG18, BG19, H45I and H45II (nutral ones). Fermentation tests were positive for lactose by BP15, glucose and ribose by BL3, and all the sugars except lactose by BG3II, BP5 and BP6. The tests were negative for protein hydrolysis by BG3II, BL5, BG18, BG19, BP10, BP11, BK2 and

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H45II ; starch hydrolysis by BG3II, BP5, BP6, BG1, BG7II, BL3, BG19, H45I and H45II ; and nitrate reduction by BG1, BG7I, BG7II, BL3, BL4, BL5, BG19, BP10, BP11, BK2 and H45II. Only acid production was studied in case of non-nodulating isolates ; 15 were neutral and the remaining 12 were acid producers.

On the basis of above findings, an attempt was made to prepare a simple practicable chart for the identification of confirmed isolates, which were classified into 4 groups according to their generation times as mentioned earlier. First group isolates (BG3II, BG11, H45J, BP5 and BP6) can easily be identified merely on the basis of colony colour in congo red YEMA. Second group isolates have been sub-grouped as colourless (BG1, BG7I and BL4) and coloured (BG7II, BP15, BL3, BL5, BP2 and BK2) forms. Members of former and later sub-groups can be identified on the basis of acid production and colony characteristics (colour and size), respectively. Third group isolates have also been sub-grouped as colourless (BG19 and BP11) and coloured (BG18, BP10 and BK2) forms and they can be identified on the basis of colony size and acid production. Fourth group (H45I and H45II) can be differentiated on the basis of just acid production.

II. Examination of physico-chemical characteristics of carrier materials

Materials examined were undecomposed droppings of cow, sheep and goat from Jobner, decomposed droppings of sheep and goat from Udaipur, 'Gobar' gas plant slurry from Kolna (Varanasi), pressmud from Aurai (U. P.), coal from Singrauli (M.P.), lignite from Neyveli (T. N.) and peats from Assam and Kashmir. Usings standard sieves of American origin, samples of various mesh sizes were prepared from the dried materials.

Physico-chemical characterisation of six mesh sizes (17, 60, 80, 100, 120 and 140) for the undecomposed droppings of cow, sheep and goat was done in respect of bulk density, particle density, porosity, water holding capacity, organic matter, total nitrogen, P_2O_5 content, ash content, electrical conductivity and C/N and C/P ratios.

Substantial increase in bulk density occurred with increase in mesh size but sheep and goat droppings were lighter than cow dung. Particle density increased with increase of mesh size for cow dung and the values of particle density for the materials were in the order of Cow > sheep > goad. Water holding capacity and porosity were correlated with mesh size inversely and directly, respectively. However,

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from the point of view of both characteristics sheep droppings appeared more suitable. When the 80 mesh size decomposed and undecomposed droppings of the animals were compared for their physical attributes, sheep manure appeared more desirable.

Sheep and goat droppings had more organic matter and nitrogen than cowdung because the cowdung samples had unusually very high content of ash. With increase in mesh size, organic matter, electrical conductivity and nitrogen decreased while ash content increased. Value of EC was more in case of goat droppings. Mesh size above 80 provided high value of P_2O_5 content for these materials; but the correlation between mesh size and P_2O_5 content was positively significant for only goat droppings. C/N ratio was fairly low for all the droppings. As the particle size (higher mesh) decreased, C/N ratio dropped down: and the corresponding correlation was significant for cowdung. C/P ratio was very high upto 60 mesh size materials; abrupt decrease occurred at 80 mesh size; then the decrease continued with increase in mesh size. All the materials were not in the mineralization phase, hence addition of some water soluble phosphate would be desirable.

Comparative evaluation of physico-chemical characteristics of all the eleven carrier materials was simultaneously done for 80 and 100 mesh sizes. In view of this comparison sheep droppings (decomposed), goat droppings (undecomposed), pressmud, cowdung slurry and peats appeared more promising than cowdung, goat droppings (decomposed), sheep droppings (undecomposed), coal and lignite as carriers in the preparation of bacterial inoculants. None of the carrier materials either of 80 mesh or 100 mesh had pH 7.0. For some the pH was above 7.0 and for others it was below 7.0. Therefore, amount of N/10 H_2SO_4 or $CaCO_3$ required to neutralize 100 gram of each carrier material was determined.

III. Evaluation of suitability of carriers and the required conditions for rhizobial inoculants

Survival and growth of 7 selected isolates was studied in sun-dried cowdung of 100 mesh at 50% water holding capacity. Initial counts ranging from 10^5 to 10^6 per gram of carrier increased to counts ranging from 10^8 to 10^9 within 3 days for H45J and BG1. In the next 7 days population counts were decreased for all the isolates except H45J, which maintained good population. Population increased slowly in case of BG19, BK2, BL3 and BP10 but did not go beyond 10^7 for most of them.

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Suitability of all the eleven carriers of 80 mesh size was adjudged at 28°C and 50% W. H. C., taking BK2, an isolate of choice because of its unique colony colouration. Population increased upto 10 days and then decreased gradually between 10 and 150 days. For 0 to 10 days, suitability of carrier followed the order : goat dropping > sheep manure > Kashmiri peat > pressmud > Assami peat > cowdung slurry > goat manure > sheep droppings > lignite coal > cowdung. For 10 to 150 days, the order of suitability was : pressmud > cowdung slurry > goat manure > Assami peat > Kashmiri peat > lignite > coal > sun-dried sheep droppings > sheep manure > sun-dried goat droppings > sun-dried cowdung.

Using BG1, an isolate having proved effective in field trials, effect of 80 and 100 mesh sizes of sheep manure, goat droppings, pressmud, cowdung slurry and Kashmiri peat was studied. In all cases excepting cow dung slurry, 100 mesh was better than 80 mesh. When effect of three storage temperatures was studied in pressmud 100 mesh at 50% W. H. C., population of BG1 did not increase at 4°C while 28°C proved better than 35°C for storing the carrier-based culture upto 30 days. When the three water holding capacities were tried with the same carrier and culture at 28°C, 60% W. H. C. was found more favourable than 30% and 90% W. H. C. The above findings on mesh size, storage temperature and water holding capacity were confirmed in similar experiments with H45J, an isolate that proved effective in various trials in the country.

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CHEMICAL ENGINEERING & TECHNOLOGY

MOMENTUM AND HEAT TRANSFER TO NEWTONIAN AND NON-NEWTONIAN FLUIDS FLOWING THROUGH PACKED AND FLUIDIZED BEDS

Damodar Singh

Sup. : *Dr. P. Mishra*

1. Scope

It is needless to enumerate the industrial application of packed and fluidized beds which remains always incomplete due to large number and variety of uses of fluid-particle systems. Although beds of fluidized and packed particles have been used in metalliferous work for four centuries, their modern industrial application dates from about 1940 when the process for catalytic cracking of oil feed stocks was introduced. The current use of fluidized bed systems in chemical processing and its possible use for reactors gives ample incentive for a full scientific enquiry into the characteristics of these systems. In nearly every case both the momentum and heat transfer are important and for design purposes adequate data are vital.

The flow of fluids like gases and Newtonian liquids were the subject of numerous researches resulting in useful correlations. On the other hand there are comparatively very few investigations dealing with the problem of non-Newtonian flow through packed and fluidized beds. There are several important practical applications, notably in the flow of oil through porous rocks, in filtration of solids from non-Newtonian liquids and in the flow of non-Newtonian liquids through ion-exchange beds. In some instances fluidizing fluid may be non-Newtonian liquid as in the production of microbial mass in certain types of fermentor and in the extraction of metals from leached pulps by ion exchange without prior filtration. In order to attain a higher heat transfer rate packed/fluidized bed may be advantageous instead of a simple tubular equipment for heating a viscous non-Newtonian.

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Earlier pressure drop studies on packed bed indicated the wide acceptance of Ergun equation for Newtonian fluid and its extension for non-Newtonian fluids has been successfully made in recent years. The tortuous path factor for packed bed has been empirically found to be 25/12. Under expanded bed conditions the tortuous path factor should depend upon voidage of the bed. The information regarding this is meagre and needs special attention. It is also important to know the fluid velocity at which the bed is about to expand or the bed is about to be entrained. These velocities are designated as minimum fluidizing velocity or maximum fluidizing velocity respectively. The latter velocity is normally taken as free-falling velocity. Free fall condition and the onset of ideal particulate fluidization are in many respects similar situations. It seems logical that there should be a correlation between the fluid velocities in these two limiting cases. Prediction of the minimum fluidization velocity and the extent of bed expansion in liquid fluidized beds has received considerable attention where the fluidizing liquid is Newtonian. Further work is needed to study the influence of non-Newtonian properties upon (i) the flow rate-pressure drop relationship in fixed and fluidized beds, (ii) the free fall velocity, and to investigate its influence upon the minimum fluidizing velocity and bed expansion in fluidized state.

The experimental heat transfer studies have been divided into two categories: fluid-to-particle heat transfer and surface-to packed/fluidized bed heat transfer. Surface-to-bed heat transfer is of particular interest in the present study. Heat transfer coefficient from a surface to a gas in a gas fluidized bed have been reported to be many times larger than the corresponding coefficients for one phase flow. This increase in heat transfer is attributed to the increased turbulence which the fluidized bed offers as well as the energy transferred by solids in contact with the surface. In packed bed condition heat transfer increases only slowly with increasing fluid velocity. An abrupt increase in heat transfer is observed as soon as fluidization commences. The increase becomes less and less marked and after passing through a maximum heat transfer rate declines. The occurrence of a maximum is explained by two opposing mechanisms-(i) increase in turbulence with increasing flow and (ii) increased bed volume with increasing flow leading to lower interstitial velocity.

Despite the significance of the property "high heat transfer rate at heating and cooling surfaces" and the relatively large effort expended in measuring fluidized-bed heat transfer rate correlations of heat transfer coefficients have remained empirical. A mechanistic approach to this problem is confronted with the complexity of the fluidization dynamics.

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However, the mechanistic analysis of wall to bed heat transfer needs more emphasis. This is possible by considering the bed structure and abrupt change in wall region bed structure at the onset of fluidization. This might explain the reason for abrupt increase in heating/cooling surface heat transfer coefficient on the commencement of fluidization. Further, investigations on heat transfer problems in packed and fluidized bed involving non-Newtonian fluids are not available in literature. This work presents theoretical explanations for tortuosity factor, effective thermal conductivity in the core and wall region of the bed, variation of bed structure in the wall region and utilizes the channel flow model to explain hydrodynamics and resistance in series model to explain bed and wall region resistance.

2. Experimental

Experimental data on wall to bed heat transfer are available in plenty for gas-solid system, very few for liquid-solid system and none for non-Newtonian fluid. One of the chief aims of the experimental part of the present work was the investigation of the effect of non-Newtonian behaviour upon the pressure drop, bed expansion and wall to bed heat transfer coefficient. Glass spherical particles of 0.1486, 0.18228, 0.2401 in. diameters and fluids : water, 2.5%, 3.5% and 4% CMC and 14% and 22% Solidiumsilicate in water were used. Flow behaviour index of the fluids ranged from 0.558 to 1.11. These particles were fluidized in 1.988 in I. D. copper pipe which was heated with a uniform heat flux.

The wall temperatures were measured by 10, 32 gauge copper-constantan thermocouples attached at even intervals along the outer wall of the copper pipe. The electric power input and the sensible heat gain of the fluid agreed to within $\pm$ 5%. All the fluidized bed heat transfer experiments were conducted at almost constant bed height. The porosity was adjusted by adding known weights of the particles. Porosity was varied from 0.41 to 0.8. Heat transfer coefficient was calculated from heat flux and temperature driving force. Reynolds number varied from 1.78×10^{-3} to 7.0×10^{3}.

3. Theoretical Findings

(i) Experimental void fraction of a bed packed with spherical particles has been found to vary from 0.39 to 0.41. Orthorhombic array of particles giving a void fraction equal to 0.395 seems to be a reasonable approximation of the packed bed structure.

(ii) Assuming the bed structure to remain orthorhombic in both the packed and fluidized bed conditions the tortuous path factor

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β (defined as the ratio of the effective length of the fluid path in the bed to the bed length) has been evaluated by considering the contraction-expansion losses in the bed. At a void fraction ϵ,

$$\beta = \tfrac{4}{3} + (a/\sqrt{\epsilon}\,\pi^{1/3})\,(1+\epsilon)\,(1-\epsilon)^{1/3}\,(2.74+\epsilon)^2$$

(iii) Ergum equation is modified for its application to expanded bed with non-Newtonian fluids

$$f_m\,(\beta_o/\beta) = 150/N_{R'ep} + 1.75$$

(iv) A new approach for expressing fluidization Reynolds number $N_{Re'p}$ in terms of a newly defined dimensionless group "friction Reynolds number" N_{R^*e} is presented as

$$N^2_{R'ep} + 80.716\,N_{R'ep} - 7.143\,N_{R^*e} = 0$$

(v) An expression for minimum fluidizing velocity is obtained in terms of Galileo number $N_{G'a}$ which is given by

$$N_{R'em} = 42.86\,(\sqrt{1 + 3.11 \times 10^{-4}\,N_{G'a}\,F(n,\epsilon)} - 1)$$

where $F(n,\epsilon) = (\beta_o/\beta)\,(\epsilon_f/6\beta)^2\,(1-n)/n \left(\frac{4n}{3n+1}\right)^2 \left[\frac{\epsilon^3}{(1-\epsilon)^2}\right]$

(vi) Maximum fluidizing velocity or free-fall velocity is given by

$$N^2_{R''et} = \frac{3}{4C_D}\,(X_{avg}\,18^{1-n})^{-2/n}\,N_{G'a}$$

(vii) The ratio of terminal velocity to minimum fluidization velocity is obtained as

$$v_t/v_{mf} = \frac{N_{R''et}}{N_{R'emf}} \cdot \frac{4n}{3n+1} \cdot \frac{X_{av}^{1/n}}{(1-\epsilon_{mf})}\,(3\epsilon_{mf}/\beta)^{(1-n)/n}$$

For low Reynolds number ($N'_{Rep} < 10.0$)

$$v_t/v_{mf} = \frac{(3n+1)}{n}\,\frac{1-\epsilon}{\epsilon^2}\,(f/\epsilon X_{av}3^{1-n})^{1/n}$$

and for high Reynolds number ($N_{R'ep} > 10^3$)

$$v_t/v_{mf} = (5.25\beta/\beta_o\epsilon^3)^{1/2}$$

(viii) A model is proposed for the explanation of the change in the bed structure at the wall. The model suggests that the void fraction ϵ_w near the wall = 0.597 while the bed-core-region void fraction remains at 0.395 and at the onset of fluidization the void fraction abruptly changes from 0.597 to 0.395.

(ix) Expressions for stagnant effective thermal conductivity in the bed and in the region near the wall have been derived for various conditions of the particles namely with gap and without gap between the particles and the surface. These expressions are useful for evaluation of the bed resistances. The following two derived relationships have

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been used for the evaluation of the stagnant effective thermal conductivity for expanded beds in the present work.

(a) Core region of the bed where void fraction $= \epsilon$ (orthorhombic model)

$$\frac{k^o_e}{k_f} = \frac{1.813}{(\lambda-1)^2}\left[B(\lambda-1) - \ln\left\{ B(\lambda-1)+1 \right\}\right] + (1 - 0.9065\, B^2)$$

where $$B = \left[3\sqrt{3}\,\frac{(1-\epsilon)}{\pi}\right]^{1/3}$$

(b) Wall region of the bed where void fraction $= \epsilon_w$

$$\frac{k^o_{ew}}{k_f} = \frac{1.813\, B^2}{(\lambda-1)^2}\left[(\lambda-1) - \ln\lambda\right] + (1 - 0.9065\, B^2)$$

(x) In order to explain the mechanism of wall to bed heat transfer a "Resistance in series" model has been proposed. The solution of the formulated differential equation and its simplification results in the following final form

$$\frac{1}{h\, D_p/k_f} = \frac{1}{\dfrac{h_w^* D_p}{k_f} + \dfrac{2\, k^o_{ew}}{k_f}} + \frac{1}{\dfrac{8 D_p}{D_t}\cdot\dfrac{k_{er}}{k_f}}$$

where k_{er} is effective radial conductivity and is given by

$$k_{er}/k_f = k^o_e/k_f + \alpha_m\, \beta_m\, (N^o_{Pr}\, N^o_{Rep})$$

(xi) The wall film coefficient h_w^* is obtained by proposing a mechanism analogous to that which occurs in the entrance region of tube in both the laminar and turbulent flow regions. The final form of the expression is

$$\frac{h_w^* D_p}{k_f}\,\frac{\epsilon_w^{2/3}}{(1-\epsilon)^{b/3}} = C\left(\frac{D_p\, v_s\, \rho}{\mu}\right)^m (N_{Pr})^{1/3}$$

The constant b has to be determined experimentally. The wall region hydraulic radius for heat transfer model is based on the heat surface and is found to be

$$r_{Hw} = \frac{D_p}{2}\,\epsilon_w$$

where $(1 - \epsilon_w) = 0.8457\,(1-\epsilon)^{2/3}$

4. Conclusions and Significance

The channel model proposed by Carman for packed beds appears to apply for both the laminar and turbulent flow region for packed bed. The capillary flow model of a particulate bed has been combined with rheological data from a capillary tube viscometer to interpret flow rate pressure drop results for fixed beds. The tortuous path factor β is found to decrease with an increase in void fraction. Inclusion of the

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tortuous path factor in Ergun equation makes it possible to use the same modified Ergun equation for both the packed and fluidized beds. The relationship is seen to be equally applicable for a non-power law fluid by using effective viscosity evaluated at the mean shear stress in the bed. The model also provides a correlation for the minimum fluidization velocity and for expansion of homogeneous fluidized beds. The resulting correlation shows that the minimum fluidizing velocity depends upon flow behaviour index of the fluid also.

A new definition of generalized friction Reynolds number N_{Re}^* and modified Galileo number $N_{G'a}$ is proposed. The use of friction Reynolds number and modified Galileo number which depend upon fluid and solid properties only makes the predictions of minimum fluidization, bed expansion and pressure drop simpler. This work has also shown that the ratio of the terminal velocity to minimum fluidizing velocity is a function of void fraction ϵ_{mf}, flow behaviour index n and of the modified Galileo number $N_{G'a}$. At higher Reynolds and Galileo numbers the ratio v_t/v_{mf} is found to be independent of both the Galileo number and flow behaviour index of the fluid. In creeping flow and in intermediate regimes the value of v_t/v_{mf} is found to increase with the increase in non-Newtonian behaviour (or with the decrease in flow behaviour index n).

The change in the structure of the bed near the wall region at the onset of fluidization makes it possible to give some explanation regarding the abrupt increase in heat transfer when the bed state changes from packed to fluidized. The wall region void fraction decreases from 0.597 to 0.395 allowing lower cross-sectional area for flow. This increases the interstitial velocity thereby increasing the wall film coefficient.

Stagnant effective thermal conductivity for various cases are seen to be a function the ratio k_s/k_f and void fraction of the bed. For $k_s/k_f > 1$, k_s/k_f is found to increase with the increase of k_s/k_f and decrease of ϵ. Series resistance model has been found to give a reasonable explanation of the overall mechanism of heat transfer from the wall to bed.

Effective radial conductivity is found to be a function of k^o_e/k_f, particle Reynolds and Prandtl numbers and a function of void fraction and Galileo number. The proposed model for the explanation of the mixing factor ($\alpha_m \beta_m$) is seen to be successfully correlated by the Wasmund and Smith data. The factor ($\alpha_m \beta_m$) is found to be a function of void fraction and Galileo number.

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Wasmund and Smith correlated the data on effective radial diffusivity showing separate correlation for Al and glass beads, the latter giving 22.5% higher value than the former. The present theory correlates the Wasmund and Smith data by a single correlation with a standard deviation of 11.5%. The proposed mechanism for the evaluation of the wall film coefficient on the basis of the entrance region flow heat transfer is not unreasonable because the flow on the wall is not a continuous flow but it is obstructed by the presence of particles on the wall. A new definition of the hydraulic radius and the wall region void fraction correlates the present and previous Newtonian fluid data well. The proposed mechanism correlates the data of Wasmund and Smith by a single correlating equation instead of separate correlations for glass and aluminium systems giving an average deviation of 8.5%.

Newtonian data are seen to fall in turbulent flow region agreeing with the conventional value of $m = 0.8$, whereas, non-Newtonian flow heat transfer data are seen to fall in laminar flow region. The Reynold index m is found to be 1/3. Entrance region heat transfer model is found to be successfully extended for power law fluids flowing in laminar fashion through a particulately fluidized bed. The theoretical model correlates the data with an average deviation of 9.5%

Finally, the correlation of the wall film coefficient h^*_w shows that it is a function of Reynolds number, Prandtl number and wall void fraction. It is observed that there exists a maximum in h_w^* as void fraction increases for each particle size. It is quite possible to evaluate $h^*_{w\,max}$ by combining the Ergun equation and the correlation for h_w^*. Differentiating h^*_w with respect to ϵ and equating it to zero, results in ϵ_{max} giving $h^*_{w\,max}$.

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CIVIL ENGINEERING

INSTRUMENTATION AND APPLICATION OF ULTRASONICS IN GEOTECHNICAL STUDIES OF SOILS

M. P. Jakhanwal Sup : *Dr. R. B. Singh*

Ultrasonics is a branch of Applied Physics. Technologically, it is multidisciplinary in nature, having versatile applications in all branches of engineering. However, its application in geotechnical studies of soils is still in a developing stage. Research and development effort is needed for the development of suitable techniques and apparatuses for conducting ultrasonic measurements in soils for geotechnical purposes.

The present thesis is a resume of the work in the above mentioned field of research. It describes the details of two ultrasonic apparatuses, viz., Ultrasonic Monitoring Consolidometer for soil testing (UMC), and Ultrasonic Monitoring Triaxial Apparatus for soil testing (UMTA) developed during the course of the present research. These apparatuses measure the conventional consolidation and shear deformation properties of soils along with their P-wave acoustical properties* along chosen stress paths. Ultrasonic measurements are a common special feature of both the apparatuses, and they help in establishing the interrelationship between acoustical properties and certain geotechnical properties of soils such as : bulk compressibility, shear strength, shear modulus, coefficient of volume compressibility, compression index, and void ratio. The measured acoustical properties are the acoustical velocity and the acoustic emission voltage.

The tests were conducted with the above apparatuses on local Ganges silt and its silt-clay matrices. The clay used was kaolinite. The matrix composition was controlled by adding a known weight of clay in a known weight of silt With the help of the test results obtained for different silt-clay matrices, it was shown that the acoustical velocity of soils can be used in predicting the stages of saturation of triaxial soil samples during back pressure applications, and in monitoring certain geotechnical properties.

* Throughout the text 'P-wave acoustical properties' has been referred to as acoustical properties only.

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Studies on acoustic emission characteristics, expressed in terms of normalized value of change in acoustic emission voltage, were also conducted on a few silt-clay matrices, with UMTA. The test results obtained indicated that the emission characteristic values can be employed in the monitoring of saturation stages of triaxial soil samples during back pressure applications and of the safety stages during deformations of the sample under triaxial system of stresses.

One of the direct applications of UMTA is in offshore geotechnical engineering. It is proposed to determine the shear modulus of off-shore soils with the help of acoustical data. For this purpose, undisturbed off-shore soil samples were procured through the Oil and Natural Gas Commission, Off-shore Project, Bombay High, Bombay (India). The results of the test, conducted on these soil samples indicate, that in addition to soil type, the characteristic carbonate content is also one of the factors which governs the acoustical and geotechnical properties of such soils.

Finally, representative scanning electron microscopic studies were also conducted for determining the shape and size of pores of the soils tested. These studies were required to check whether any correction was needed for converting the laboratory acoustical velocity values which were at chosen ultrasonic frequency, to the low frequency in-situ acoustical velocity data usually collected by the geophysicists during the surveys of sea-bed materials.

The research findings reported in the thesis are multi-directional in nature, each one pointing towards a minor area in which future exhaustive researches can be taken up, ushering an era of geotechnical engineering of remote monitoring and prediction of geotechnical properties of soils by means of quicker non-destructive tests.

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ELECTRONICS ENGINEERING

MICROWAVE PERMITTIVITY MEASUREMENT TECHNIQUES

Manjari Modwel Sup. : *Dr. R. K. Jha*

Precise measurement of complex permittivity of materials has a growing demand in the field of microwaves because of satellite communication, in the quality control of materials when these properties (dielectric constant and loss tangent) vitally affect the performance of the completed system. Permittivity measurement is playing an important role in the biological systems especially for disease diagnosis. Due to the importance of the dielectric parameters in various fields, precise measurement of permittivity of materials is very much desirable. A number of techniques are existing for measurement of dielectric parameters (of solids, liquids and aerosols) at microwave frequencies. These techniques are based on the type of materials and the frequency range of interest. On account of the wide range of parameters of various materials, all the available methods are not suitable for each material and hence there is a need for investigation by exploring more accurate and precise techniques of permittivity measurement. Measurments of permittivity are mainly based on the principle of transmission line methods, cavity methods, cavity perturbation methods and free space methods. However, there are numerous techniques available in literature based on one of the above principles for measurement of permittivity of materials at microwave frequencies.

The author in this thesis has suggested a few techniques of measurement on the basis of transmission line principle and cavity perturbation method. All the measurements are in the X-band of frequencies using different microwave passive components on the basis of this principle. Some of the modified techniques are given in Chap. 1 using a crosscoupler and precision sliding short, a magic tee and precision sliding short including two magic tees and precision sliding shorts. One simplified method of permittivity measurement using cavity perturbation technique is also proposed. This is with respect to the placing of the sample inside the cavity in the region of maximum electric field which is done by means of fine hair suspension (for tiny spherical and rectangular samples). Further, few microwave bridges are used for the measurement of dielectric constant and loss tangents.

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Besides this, attempts have also been made to measure the permittivity of a few liquid samples using partially filled wave guides and a technique is also suggested for measuring dielectric parameters using a crosscoupler, an H-plane tee junction and sliding shorts.

Some of the results of the techniques under investigation are given in the tabular form below as examples.

Results of Different Modified Techniques
(from Chapter 3)

Sample	Cross-coupler technique		Magic-tee technique		Cross-coupler H-plane tee technique	
Lithium Fluoride	8.53	1.421	8.606	1.469	8.56	1.462
Napthalene	2.405	0.291	2.407	0.31	2.403	0.27
Sugar powder	2.087	0.261	2.091	0.27	2.093	0.26
Kerosene	2.069	0.027	2.053	0.027	2.055	0.024
Potassium Bromide	4.836	0.19	4 808	0.083	4.873	0.19
Petrol	1.996	0.019	1.990	0.019	1.994	0.017
Castor Oil	2.726	0.308	2.71	0.302	2.705	0.306
Ganges sand	2.557	0.032	2.563	0.028	2.558	0.032

Results Obtained by Different Alternative Techniques
(from Chapter 4)

Sample	Two-Magic Tee Technique		Cross-coupler		Slotted-line Technique	
	ϵ^I	ϵ^{II}	ϵ^I	ϵ^{II}	ϵ^I	ϵ^{II}
Lithium Fluoride	8.94	15.25	8.57	15.44	8.16	15.30
Napthalene	2.30	0.35	2.49	0.47	2.45	0.42
Sugar powder	2.12	0.73	2.10	0.61	2.03	0.68
Potassium Bromide	4.85	0.21	4.83	0.28	4.70	0.94
Ganges sand	2.51	0.79	2.57	0.85	2.55	0.81
Kerosene	2.05	0.61	2.04	0.58	2.00	0.50
Petrol	2.00	0.22	2.03	0.20	2.07	0.21
Castor Oil	2.75	0.17	2.73	0.22	2.69	0.54

In addition to above, the limitations of some of the techniques utilised here are also pointed out in the conclusion. Moreover, suggestions for future investigation are also given.

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LABORATORY SIMULATED MICROWAVE REMOTE SENSING STUDIES

Krishna Kumar Jha Sup : *Dr. K. P. Singh*

The emergence of Remote Sensing as a tool for mapping earth's surface and studying the structure and composition of its interior has revived various types of laboratory measurements and theoretical studies. Detailed knowledge of electromagnetic response in the extended frequency range help the investigators to recognise the target exactly in the same way as the bank agent recognises the payee by his signature. This analogy has been aptly used and the science of target response is known as Remote Sensing Signature Analysis. In the present study, efforts have been made to study the microwave response of earth-forming material and the water surface with oil slick. Some basic measurements of materials and leaves have been made. The bistatic scatterometer system has been used in this investigation as used by many workers in this field of study. A limited number of backscattering observations have been made using monostatic scatterometer system. The thesis contains five chapters. The first chapter gives an overview of totality of the subject of remote sensing with emphasis on the microwave remote sensing. Scope of this study has been outlined and importance of this study has been discussed.

In addition to the introductory chapter, the thesis contains four chapters which describe the results of various measurements made in the laboratory. The measurements have been made in the X-band (9.52 GHz) of microwaves. We may mention that we had no choice in the selection of X-band because of availability of X-band and non-availability of other frequency bands in the laboratory. Therefore, throughout this investigation we have used a fixed frequency in the X-band. Thus, we neither claim the superiority nor better applicability of X-band studies to problems of remote sensing. However, we have noted that maximum number of remote sensing studies have been carried out in the X-band of microwaves by many workers. The following four chapters present the sequential development of this study.

In the second chapter, we have described some basic measurements namely the complex dielectric constant of soils and green vegetations at X-band of microwaves. Two measurement procedures have been followed. Using 'infinite sample method' we have studied the effect of soil texture on dielectric constant. This effect has been demonstrated by other workers also (Lundien, 1971; Newton, 1976;

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Wang and Schmugge, 1979). We have measured the dielectric constant of composite soil samples by varying the percentage of its three basic constituents, such as coarse, medium and fine grains in a definite order. The measured data have been analysed in the light of various empirical formulae for representation of complex dielectric constant of a mixture with known percentage. The measured data support the empirical formulation for dielectric constant of mixtures as given by Birchak et al. (1974) and Lichtenecker-Rother (Tareev, 1975). The effect of moisture on the complex dielectric constant of soils have been studied, and it was found that with the addition of moisture in soil, the effect of soil texture is overshadowed. The earth's upper layer, in general, is covered by green vegetation ; therefore, the knowledge of dielectric constant of vegetation is very important in the overall analysis and interpretation of airborne and spaceborne remote sensing data. As such, the exact knowledge of vegetation is rather difficult, because, a vegetation cover is made up of leaves of various sizes, thicknesses and orientations. Each of the leaves in a plant may even contain different percentage of moisture. However, the problem undertaken in this chapter is the measurement of complex dielectric constant of leaves. We have used for this purpose, the Perturbation Technique which is capable of measuring the complex dielectric constant of leaf samples at various stages of its moisture, namely, starting from the freshly plucked leaf to the state of drying. Careful measurements have shown that the leaves of various plants have different dielectric constant. Further, the dielectric constant of a freshly plucked leaf is larger ; however, the value of dielectric constant was found to be different for different leaves. The dielectric constant of a given leaf was found to depend on its orientation. These results have been found to compare well with the reported results of other workers (Carlson, 1967; Fung and Ulaby, 1978).

The third chapter describes the microwave response of plane stratified layers. For this we have used bistatic scatterometer system. The system was operated in the X-band of microwave. Basically, we have made the bistatic scatterometer measurements on a model tank filled with dry soil. Then the idea was extended to study the stratified layers as seen by incident X-band microwaves within the limit of skin depth. Three layer stratification and various combinations of sand-silt-stone, and sand-silt-metal plate-stone were used in this measurement. The sequence of stratification was changed and measurements were taken. We have found that the stratification changes the reflectivity and its corresponding brightness temperature from one

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sequence to another. The effect of moisture was also studied. These stratified layers were approximately plane and uniform, therefore, results were analysed using reciprocity theorem. The Brewster's angle changed slightly from one sequence to another which depicted the dielectric constant of the upper interface. The study of stratified layers has great relevance to practical situations faced in practice. The earth's crust is, in general, stratified with various layers of different composition, structure and thickness. These results do not include the effect of multiple reflections from the stratified interfaces. Therefore, based on these measurements and analysis of these data, we feel that in the case of stratified layers the Radiative Transfer theory is best suited for the analysis and interpretation of measured data in particular and Remote Sensing satellite data in general.

In the fourth chapter of the thesis, we have highlighted the various parameters such as, soil moisture, surface roughness, dielectric constant fluctuation etc. which affect the microwave sensor response. Soil moisture plays an important role in a number of disciplines, including hydrology, agriculture and meteorology (Idso et al., 1975a; Schmugge, 1980). For these and other applications the knowledge of soil moisture is essential. It has been shown that around Brewster's angle the vertical polarization does not decipher clearly the dry ground from the moist ground although the shift in Brewster's angle is measurable. We have also carried out scattering study from a slightly rough surface characterized by certain height distributions. The open field surfaces satisfy the Rayleigh's criterion and make the surface slightly rough and in such cases, we have measured the backscattering response. The measurements also show how the plane surface Fresnel's reflection coefficient is modified due to surface roughness. The backscattering cross-section (σ^0) measurement for slightly rough surface, with moisture shows that for both VV and HH-polarizations the value of σ^0 above 40^0 look angle is not so prominent, i. e., the σ^0 value at lower angle is larger and decreases monotonically. We find that the addition of moisture increased the backscattering response. The above measurements were carried out on outdoor field site. Similar scattering measurements have been carried out by creating the dielectric constant fluctuations. We have created some scatterning pattern by putting rows of iron balls (size 1/8") on the plane homogeneous sand surface which produces dielectric constant fluctuations. The look angle variation of reflectivity was measured for two systems of iron ball arrangements :

(i) rows of iron balls paralliel to trans-receiver line

(ii) rows of iron balls perpendicular to trans-receiver line.

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The measured reflectivity showed some oscillatory behaviour which arises due to interference of diffracted power. At the same time these undulations were found to be minimum when the spacing between the rows was less than the operating wavelength. With monostatic scatterometer arrangement, σ^0 was measured for the same patterns of iron balls as used for reflectivity measurement. It was found that when the electric field is parallel to row direction, less power was scattered in the backward direction while reverse was true when electric field was perpendicular to row direction These measurements with surface undulation and dielectric embedding provide the basic understanding of some of the natural targets. The effort made in this chapter is no doubt meagre but we found it very difficult to interpret the observed variations. Only a preliminary interpretation in terms of diffraction and interference of microwave signal as cause of observed undulations has been proposed. We feel, detailed response from modelled rough surfaces and dielectric fluctuations would be very helpful in analysing and interpreting the remote sensing data using airborne and satellite borne radiometer data.

In the fifth chapter we have presented the effect of oil slick on the reflectivity as well as on the backscattering coefficient (σ^0). For this study we have used model tank filled with water having salinity approximately equal to the practical salinity of ocean and the measurements have been carried out in the X-band of microwave. The reflectivity data has been obtained under calm as well as quasi calm water surface conditions. The effects of oil film on the tank surface have been studied. The air-oil-water interfaces have been modelled to compute the practical response of oil film. The theory of n layer medium is well known (Brekhovshikh 1960). The theoretical detail of air-oil-water interfaces has been given by Aukland et al. (1969), Hollinger (1974) and Singh and Lal (1981).

The measured reflectivity data with varying oil slick thickness gives an oscillatory behaviour, which shows that the thickness of oil slick can be estimated by using aircraft or satellite borne sensors over the open ocean. Although open ocean is not strictly calm, these results give a primary insight into the brightness temperature of ocean surface. It is shown that as oil slick thickness over water surface increases, the brightness temperature increases. The results have been compared with theoretical results as well as experimental results obtained by other workers and we observe that the nature of variations is similar to that reported by other workers (Hollinger, 1974; Singh and

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Lal, 1981). Further, we have made some backscattering cross-section (σ^0) measurements with small surface undulations which according to Rayleigh's criterion behaved as a quasi calm surface. From the limited number of measurements we find that the backscattering cross-section (σ^0) values decrease when oil slick thickness increases. We have compared these results also with the results of some other workers and we find that these measurements depict similar variations apart from significant changes in the magnitude of the measured backscattering cross-section (Van Kuilenberg, 1975; Nelepo, 1977; Johnson and Croswell, 1981).

The measurements reported in this thesis are the first effort made in this direction of co-ordinated microwave response from various types of interfaces. We have faced innumerable problems and solved them as a process of learning. The results of these measurements have been presented in various National and International symposia and our efforts were highly appreciated. We feel that very good simulation studies can be made by using quality controlled and automatic experimental set up. However, our effort was fully manual and thus it was highly time consuming. Such measurements have very high potentiality and we feel that it should be carried out in the extended frequency region under various controlled conditions.

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METALLURGICAL ENGINEERING

STRUCTURE OF RAPIDLY QUENCHED ALUMINIUM ALLOYS

Zariff A. Chaudhury Sup. : *Dr. C. Suryanarayana*

Techniques of rapid solidification have received the serious attention of scientists and engineers in recent years to develop new and improved materials. It has been shown that by rapidly quenching metallic melts at rates exceeding about a million degrees Celsius per second (referred to variously as melt quenching, splat cooling, liquisol quenching etc.), supersaturated solid solutions, metastable intermediate phases and even metallic glasses can be produced. The magnitude of interest in this field is well appreciated by the fact that well over 4000 research papers have been published during the last twenty years on various aspects of these rapidly quenched alloys. In spite of the world-wide activity on production and characterization of metallic glasses in view of their potential industrial applications, there has been renewed interest recently on metastable crystalline alloys.

The Rapid Solidification Group at Banaras Hindu University has been very active during the last decade or so in understanding the reasons for the formation and details of decomposition behaviour of metastable phases in aluminium-base alloys Systems so far investigated include those based on aluminium containing Ag, Bi, Cd, Cu, Ge, In, Mg, Ni, Pd, Pt, Si and Zn. These studies helped in delineating common features observed during the decomposition of supersaturated solid solutions. Continuing this trend Al-Ru, Al-Rh and Al-Zr binary alloy systems have been investigated and the results obtained by melt quenching and vapour deposition form the contents of this Thesis.

Chapter I of the five-chapter Thesis gives a brief summary of the experimental techniques available for rapid solidification. Results obtained on Aluminium-Transition Metal systems are summarised and the similarities observed in different systems have been highlighted. This has been done with a view to provide the background information for the experimental results to follow in subsequent chapters.

The experimental methods used in this investigation have been described in Chapter II. The alloys have been rapidly quenched using

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the "gun" technique of melt quenching and also by vapour deposition. The resultant products and those obtained by annealing have been characterized by detailed transmission electron microscopy (both in-situ hot-stage and on externally heat treated specimens) and diffraction as also by x-ray diffraction methods.

Chapter III describes the results obtained on melt-quenched and vapour-deposited Al-10 and 15 wt.% Ru alloys. While the solid solubility limit of Ru in Al could be increased up to over 10% from the equilibrium value of 0.1 wt.% by melt quenching, the vapour-deposition technique has been shown to be effective in producing a supersaturated solid solution in the Al-15 wt.% Ru alloy also. High temperature annealing of these metastable solid solutions resulted in the formation of equilibrium phases via metastable phases. Two such cubic phases — one of the CaF_2 type Al_2Ru with $a = 0.563$ nm and the other of the Mg_2Zn_{11} type $Al_{11}Ru_2$ with $a = 0.84$ nm — have been characterised in this chapter. Detailed electron microscopy work is reported to describe the morphology of the non-equilibrium and the equilibrium phases. The equilibrium constitution for these alloys has been shown to be a mixture of Al and Al_6Ru phases.

The results of the investigation on an Al-2 wt.% Rh alloy subjected to melt quenching and vapour deposition are described in Chapter IV. Supersaturated homogeneous solid solutions have been obtained in both the cases, which were stable up to about 650 K. Precipition of an intermediate phase having a monoclinic structure with $a = 1.636$ nm, $b = 0.805$ nm, $c = 1.279$ nm and $\beta = 107.77^0$ and a possible stoichiometry of $Al_{13}Rh_4$ has been detected during the decomposition of the supersaturated solid solution. The morphology of the metastable phases formed and their eventual transformation to the equilibrium phases are followed through hot-stage electron microscopy. Very long annealing treatments at 773 K resulted in the formation of an ordered phase. The long-range order was destroyed on heating to still higher temperature. The equilibrium constitution in this alloy has been shown to be $Al + Al_{13}Rh_4$. Crystal chemical considerations have been put forward to explain the occurrence of the $Al_{13}Rh_4$ phase in this system.

Chapter V describes the results obtained on an Al-9.4 wt.% Zr alloy. The supersaturated solid solution in this case has been found to be stable up to at least 573 K. A metastable cubic ordered phase of the Cu_3Au type was found to form on annealing the melt-quenched alloys at temperatures in excess of 600 K. This phase has a typical fan shape.

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Higher temperature annealing leads to the formation of the equilibrium Al_3Zr tetragonal phase. Decomposition of the supersaturated solid solution produced by vapour deposition led to the formation of two metastable phases with the possible stoichiometries $Al_{11}Zr_2$ and Al_6Zr. While $Al_{11}Zr_2$ has a cubic structure with a = 0.85 nm, Al_6Zr has been shown to be orthorhombic with a = 0.7489 nm, b = 0.6556 nm and c 0.8961 nm. Long time annealing of the vapour-deposited thin films also resulted in the formation of the equilibrium tetragonal Al_3Zr compound.

The present Thesis is an attempt to understand the metastable behaviour of Al-rich Al-Ru, Al-Rh and Al-Zr alloys. During this investigation as many as five metastable phases have been characterized with the chemical formulae Al_2Ru, $Al_{11}Ru_2$, $Al_{13}Rh_4$, $Al_{11}Zr_2$ and Al_6Zr. These have been shown to have prototypes in the homologous systems. As such detection and characterization of the crystal structures of these metastable phases aid greatly in the classification of intermediate phases in aluminium alloy systems in addition to helping in understanding the crystal chemical principles involved in their formation. Further studies in this direction will prove useful.

NON-METALLIC INCLUSIONS IN PLAIN CARBON AND LOW ALLOY STEELS

Mohan Das Maheshwari Sup. : *Dr. T.Mukherjee*
Dr. S. L. Malhotra

Non-metallic inclusions, however undesirable they may be, are an integral part of all steel products produced by conventional technology. The deleterious influence of non-metallic inclusions on the mechanical behaviour of steels is now well known. A comprehensive knowledge of the origin, nature and distribution of inclusions is helpful in controlling them within limits.

Inclusion studies with small laboratory ingots do not give the necessary information required for controlling non-metallic inclusions in large commercial heats. The details of investigation carried out in a steel plant, as published in literature, are not adequate since vulnerable details are, normally, not reported.

Therefore, investigations were taken up to study the effect of process parameters on non-metallic inclusions in a few critical grades

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of commercially produced steel, with an objective of understanding the behaviour of such constituents. The ultimate aim was to establish a process for producing steel of superior and consistent cleanliness by conventional steel making methods. Investigations also covered a study of the mechanism of formation of bottom-cone segregation, expecting that the understanding of this phenomenon would be an additional aid to achieving the general objective of producing clean steel.

Experimental work covered steel making and ingot making in electric and basic open hearth furnaces. The following groups of steels were studied :

(i) Steel for boiler tubes,

(ii) plain carbon and low alloy steels for engineering industries, and

(iii) steel ingots for wheels and tyres for locomotives.

Effect of deoxidation and several other steel making process parameters was studied. Samples were collected during processing of liquid steel, and also from specific predetermined positions of bars, rolled from the commercial 8 tonne ingots. A few two-tonne ingots were also sectioned, and different regions were studied for inclusion analysis by optical and electron metallographic techniques. The chemical heterogeneity of these ingots was also studied.

Significant observations of the present investigation are as follows :

1. Alumina and alumina-rich inclusions decreased and silicate inclusions increased with progress of teeming. It was noticed that some of the "floating up" silica-rich inclusions were dragged with the stream being teemed out. A model has been developed to explain this phenomenon.

2. Silica-rich silicate inclusions with cristobalite precipitates or even with cristobalite rim were seen at low Mn : Si ratios when aluminium level in the steel was less than 0.015%. The nature of such inclusions changed, in the sense that they became more fluid with no discrete particles of cristobalite even at low Mn : Si ratios down to 2.6 when the level of aluminium was raised to 0.015% or higher. A mechanism has been proposed to explain this aspect and accordingly a model has been developed.

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3. It was noticed that the volume fraction of oxides in the electric furnace heats made by predeoxidation after slag-off was considerably lower, at all stages of steel making, than those in heats made by conventional double slag practice. This has been attributed to lowering of oxygen content of the melt before making the reducing slag.

4. Examination of inclusions in samples of sectioned ingots from different regions indicated the following features :

   (a) occurrence of bottom-cone of inclusions,

   (b) coincidence of shape and position of negative segregation with that of bottom-cone of inclusions,

   (c) presence of oxide inclusions, both in the dendritic and interdendritic regions of the bottom end of the ingot,

   (d) presence of large oxide inclusions at the top end of the ingot,

   (e) changing morphology of the sulphide inclusions from type I at bottom end to type III at top end of the ingot, and

   (f) coexistence of alumina and alumina-rich inclusions with type III sulphides at the top end of the ingot.

Comprehensive explanations have been advanced to account for the observed phenomena.

This investigation led to the following major conclusions :

1. Maintaining or lowering the level of soluble oxygen in liquid steel before tap is an effective way of controlling the volume of oxide inclusions.

2. In open hearth practice, the rate of carbon drop in the finishing period should be steady and around 0.20% per hour.

3. The analysis of the deoxidation products formed in a low-carbon, low-manganese commercial steel deoxidised with silicon and aluminium follows a well defined path in the MnO_2-SiO_2-Al_2O_3 ternary diagram.

4. Feasible suggestions to ensure formation of easy-to-coalesce fluid silicate inclusions, at low Mn : Si ratios, have been given.

5. In the ladle, during teeming, two opposing forces operate on the inclusions : one of flotation, the other of dragging down. Fluid inclusions stand a better chance to escape the dragging forces.

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Presence of a minimum of 0.015% aluminium, in the steels studied, improves the fluidity of the inclusions.

6. Predeoxidation of the bath after slag-off, in electric furnace heats, reduces the oxygen content of the steel; as a consequence, the reducing slag is more effective, minimising the total volume of oxide inclusions.

7. Bottom pouring flux has been found to be an effective sink for alumina-rich inclusions.

8. It is possible to predict the extent of segregation of oxide inclusions at the bottom end of the ingot on the basis of average volume fraction of oxides in the ingot.

9. The bottom cone of high melting point oxide inclusions is a result of incorporation of these inclusions in the dendrites of equiaxed grains The inclusions drop to the bottom end with the shower of relatively pure equiaxed grains. The reasons for the presence of such oxide inclusions in the interdendritic region have also been established.

10. The melting point of non-metallic inclusions, and their nature and distribution have been used to decipher the segregation mechanism in an ingot.

11. The last to solidify interdendritic fluid is enriched in carbon, sulphur and phosphorus but is depleted of oxygen. The first three elements having high solubility in the interdendritic fluid do not form precipitates, but oxygen concentration cannot increase with the progress of solidification because of precipitation of oxides due to low solubility.

12. The low concentration of soluble oxygen, indicated by the presence of type III sulphides and the presence of large oxide inclusions and alumina clusters in the interdendritic region at the top end of the ingot indicate significant movement of the interdendritic fluid towards the top end during the progress of solidification.

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PRODUCTION AND PROPERTIES OF LEADED ALUMINIUM PLAIN BEARING ALLOYS

Janardan Prasad Pathak

Sup : *Dr. S. L. Malhotra*
Co-Sup : *Dr. S. N. Tiwari*

Plain bearings constitute an important and delicate part of thousands of machinery in the present day use and determine to a great extent the life of these machines. There are a variety of materials available today for fabrication of such bearings, the most common being those of tin- and lead-base babbitt alloys, copper-lead alloys, leaded bronzes and aluminium-tin alloys. However, in general, these alloys incorporate either a costly base metal like tin or copper and/or substantial quantities of the expensive alloying addition of tin. Hence, there is a need for exploring the possibility of cheaper substitutes for these alloys having comparable or superior bearing properties.

It is well known that aluminium offers several advantages as a potential base for plain bearing alloys. It is a relatively low-cost metal and our country has large reserves of it. Its hardness and strength can be properly adjusted by minor additions to suit the requirements of a particular bearing application. On the other hand, lead is an ideal and least-expensive soft-phase alloying metal available to confer other necessary bearing properties to aluminium. Hence, technically as well as economically, aluminium-lead alloys represent the most desirable alloy combinations which have great potential for exploitation as attractive alternatives to several existing bearing alloys. It is in this context that the present investigations were undertaken to develop a series of such leaded aluminium alloys and evaluate their major bearing characteristics, so as to explore the possibility of substitution of the available expensive bearing alloys with these alloys.

There are some practical problems associated with the production of Al-Pb alloys by conventional melting and casting techniques. Aluminium and lead have a wide miscibility gap in the molten state and are virtually insoluble in each other at room temperature. Further difficulties arise from the large freezing range of their alloys and the wide density difference between the two components greatly increases the kinetics of lead segregation during alloy preparation. It has been difficult, therefore, to introduce and disperse lead uniformly in aluminium to the desired extent and so far, even with the best efforts, hardly anyone has been able to incorporate lead in aluminium alloys more than 10 wt.%. However, in this study, it has been possible to develop

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a novel technique of impeller mixing and chill casting, which has been successfully employed to disperse and retain lead uniformly up to 50 wt.% in cylindrical aluminium castings of 40 mm dia and 250 mm long. The mixing and casting equipment designed is simple enough to be readily adapted by any conventional foundry. Using the above technique, a series of lead-bearing aluminium alloys have been produced varying in lead content from 5 to 50 wt.% and differing in base metal from commercially pure aluminium to much stronger Al-Cu, Al-Cu-Mg and Al-Si piston alloys. Lead is found to occur in uniform dispersion as interdendritic or structurally independent discrete particles in the as-cast structures of these alloys, irrespective of their base alloy compositions. However, the morphology of lead is significantly influenced by the concentrations of lead and alloying elements present in aluminium-base alloys. Addition of lead also improves the castability of these alloys.

In order to characterise these alloys for various applications, a number of relevant mechanical properties of leaded aluminium alloys have been evaluated. Room temperature ultimate tensile strength, 0.2% compressive and tensile proof stresses, hardness, elongation and impact strength of the above alloys have been investigated as a function of their compositions. Impact of artificial aging, cold rolling and annealing and elevated operating temperatures on the as-cast mechanical properties of the leaded alloys have also been studied. It has been found that the hardness and strength properties of these alloys degrade, and the elongation and the impact strength improve progressively with increasing lead concentration, irrespective of the base alloy composition used. However, the rates of decrease or increase in the above mechanical properties depend on alloy composition, particularly on the amount of the lead present in the alloy. Beyond 15-25 wt.% Pb, the rate of change in properties is relatively small. It is also noted that the artificial aging of as-cast leaded alloys improves only moderately their hardness and strength properties, whereas cold rolling and annealing treatment confers a significant enhancement in the above properties. In general, it is inferred that a very wide range of mechanical properties of strength, hardness, ductility and toughness can be generated from leaded aluminium alloys by varying the composition and other process parameters.

One of the basic functions of a plain bearing is to minimise wear and/or reduce friction between two surfaces in relative motion. The wear and frictional characteristics of leaded aluminium alloys therefore, have been also studied under simulated service conditions. A pin-on-disc type experimental wear testing machine has been designed

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and fabricated for this study. Wear volume of leaded alloys has been measured as a function of alloy composition, sliding distance, normal load and sliding velocity. Temperature of the test specimen near the mating interface has been also recorded as a function of above parameters to provide an indirect measure of the friction between the mating surfaces under different sliding conditions. In general, it has been found that the wear volume or wear rate decreases with increasing lead content and hardness of a base alloy under a variety of tribological conditions, but friction does not decrease beyond a certain concentration of lead in the alloy. It is noted that lead acts as an effective solid lubricant in aluminium alloys in the concentration range of only 10-35 wt.%. Metallographic examination of the wear specimen, wear track and wear debris reveals the mechanisms of the wear damage and it is found that more than one wear process participates in the generation of the wear particles, depending upon the nature of the alloy and operating conditions.

An empirical test, referred to as 'Bearing Test', is normally adopted to evaluate the seizure resistance of plain bearing alloys—a characteristic used as a measure of the service performance of a bearing material. An experimental bearing testing machine, therefore, has been designed and used to study the above characteristics of the leaded aluminium alloys. This test has been performed under different conditions of oil lubrication and sliding and the effect of unit load on each of the bearing characteristic number (ZN/P) and the friction coefficient (f) has been investigated for different alloys. It has been found that with oil lubrication, all leaded alloys (10-50 wt.%Pb) are able to run without seizure up to high-friction regions of boundary and mixed-boundary lubrications, whereas their base alloys seize even under hydrodynamic lubrication conditions. In both semi-dry as well as dry sliding conditions, friction coefficient decreases and seizure load increases progressively with increasing concentration of load up to 25 wt.% Pb. It is also noted that a higher level of seizure load is required for a leaded alloy bearing under semi-dry conditions as compared to that of dry sliding conditions. Lead-bearing aluminium alloys also show their capacity to absorb and use a lubricating oil in reducing friction in case of the oil-supply failure.

An appraisal of the various characteristics and properties of leaded aluminium alloys shows that the new alloys are characterized by a wide range of desirable bearing properties suitable for a variety of antifriction applications. Comparison of their mechanical properties, wear resistance and antiseizure characteristics with those of commercial

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bearing alloys shows that there is a distinct possibility of the leaded aluminium alloys to be preferred to existing bearing alloys for similar bearing applications.

A UNIFIED APPROACH TO SUPERPLASTIC DEFORMATION

Raj Kumar Yadava Sup. : *Dr. K. A. Padmanabhan*

The present thesis entitled 'A UNIFIED APPROACH TO SUPERPLASTIC DEFORMATION' has been presented from a perspective. There is universal agreement among researchers in the field of superplasticity that grain boundary sliding is the dominant mode of deformation (in superplastic flow). As regards the presence of other mechanisms there is considerable controversy. Even when it is granted that there should be an accommodation mechanism, difference of opinion exists as to whether this should be diffusion or dislocation motion. Thus, it has been felt that it would be desirable to explain both the unsteady and the steady state regions of superplastic flow only in terms of grain boundary sliding. Then it is possible to minimise the number of assumptions involved and in the process minimise the risk of error. Thus a model has been developed to suggest that in the initial unsteady region of flow the grain boundary obstacles get smoothed so that continuous sliding without exhaustion can take place in the steady state region. Evidently, in this unified approach the phenomenon is explained by postulating that a single mechanism i. e. grain boundary sliding leads to superplastic flow. Then the physical picture becomes simple and the number of postulates and assumptions are reduced to a minimum.

However, this is not to say that no other explanations are possible. All that is being claimed in favour of the present approach is that the model is viable and that it is able to explain satisfactorily most of the observations concerning both unsteady and steady state superplastic flow.

For the experiments two common superplastic alloys, viz. a tin-lead eutectic alloy, produced from its constituent metals of commercial grade, which exhibits excellent superplastic characteristics at room temperature and a commercial superplastic zinc-aluminium eutectoid alloy (SPZ) supplied by ISC Alloys Limited, Bristol, England, were chosen.

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The work described here was carried out by the author in the Physical and Mechanical Metallurgy Laboratories of the Department of Metallurgical Engineering, Institute of Technology, Banaras Hindu University. A small part of the work, viz. the scanning electron microscopy of the zinc-aluminium eutectoid alloy was done at the Metallurgy Division of the Bhabha Atomic Research Centre, Bombay during a visit to Bombay.

This thesis is presented in three parts. Part I, dealing with a survey of the relevant literature, has been divided into two Chapters. Chapter-1 is concerned with the introduction to the subject of 'Superplasticity' and its relation to high temperature deformation; and this is followed by a brief note on the applications of superplasticity. Apart from this, the scope of the present work has also been dealt with in this Chapter.

Chapter-2 critically reviews developments in the areas of interest, viz. (i) the various explanations available for explaining unsteady and steady state flow in superplastic alloys, (ii) the effect of specimen geometry, (iii) the rheological concepts of superplastic deformation and (iv) cavitation and fracture of superplastic materials. This chapter points out the state of knowledge in each of these areas.

Part II, which forms the bulk of the thesis and consists of five chapters, presents the results obtained in this work and their interpretations. Chapter-3 is concerned with material selection and the experimental procedure adopted for the investigations on the two alloy systems, viz. the tin-lead eutectic and the zinc-aluminium eutectoid (SPZ) alloys. The testing procedures consisted of specimen preparation and its heat treatment to obtain specimens of different grain sizes, optical and scanning electron microscopy, mechanical testing and fractography.

Chapter-4 is related to the study of the unsteady and steady state regions of superplastic flow in case of both the above alloy systems and takes into account the effect of variables such as grain size, temperature and strain rate of deformation. It has been concluded that an unsteady region is invariably present in the initial stage of deformation. With the help of the model developed it has been possible to conclude that the picture that in the unsteady region the grain boundary obstacles are smoothed is viable and that the grain boundary diffusivity of the faster diffusing species predicted by the model is very close to what is reported in the literature based on diffusion experiments.

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Superplasticity is a thermally activated process. An attempt has also been made to systematically investigate the activation energies associated with superplastic flow to confirm the conclusions regarding the deformation mechanisms reached by other techniques. Apart from this, the influence of engineering variables such as strain rate, grain size and temperature of deformation on the shape of the true stress-true strain curve (up to and beyond the onset of steady state flow), the strain-rate sensitivity in steady state deformation, the elongation to fracture and the microstructural changes accompanying deformation have also been discussed.

In conventional plasticity the flow stress of polycrystals is very sensitive, not only to the grain size, strain rate and temperature, but also to the specimen geometry. Chapter-5 deals with an attempt that has been made to consider the effect of specimen dimensions on the flow stress and the total deformation, using strip tensile specimens of tin-lead eutectic alloy. In these experiments the gauge length, width and thickness have been varied one at a time. The studies have revealed that in a test at constant cross-head speed, so long as the strain rate did not change appreciably the steady state value of the strain-rate sensitivity index remained practically constant. A change in the width or thickness of the specimen affected the magnitude of the maximum in the true stress-true strain plots and the corresponding strain perceptibly. On the other hand, the elongation to fracture decreased with increasing gauge length but increased on increasing the width or thickness. On the basis of these experiments it was also concluded that in addition to the grain size and the temperature of deformation, the cross-head velocity/strain at which the stress-strain rate relationship is evaluated should also be specified.

In Chapter-6 the postulates of a rheological analysis of superplasticity have been verified by analysing the tensile test results on the tin-lead eutectic alloy (presented in Chapters 4 and 5). The above model envisages superplasticity to arise from the viscous flow of grain boundaries surrounding essentially non-deforming grains and the increase in stress at a given strain rate with increasing crosshead velocity/strain may be interpreted in terms of the increase in the 'apparent viscosity' of the medium. This picture reduces the superplastic alloy undergoing deformation to a condensed particulate system in which the particles (grains) get dragged along by the flowing grain boundaries. In this case the resistance to flow may be expected to increase with cross-head speed on account of the greater number of

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particle (grain) collissions per unit time. The postulates of the analysis are verified by the experimental results.

Chapter-7 deals with observations on the fracture surfaces of the tin-lead eutectic alloy, tested at room and elevated temperatures. With the aid of scanning electron microscopy, cavitation and fracture behaviour in the alloy, whose reduction in area of cross-section before failure is close to 100%, has been investigated in regions II (b) and III of superplastic flow (where both the elongation to fracture and the strain-rate sensitivity index decrease with increasing strain rate). It has been observed that grain boundary sliding persists in this range, although with decreasing importance on increasing the strain rate. At all strain rates the final failure was due to tearing by plastic flow of the inter-cavity ligaments, but the interlinkage of cavities along the grain/interphase boundaries decreased with increasing strain rate. This observation is also consistent with a decreasing role for grain boundary sliding with increasing strain rate in regions II (b) and III of superplastic flow.

Part III provides an assessment of the present results and is presented as a single chapter, i. e. Chapter 8. Here important conclusions that have emerged from the present work have been collated and presented briefly. Possible lines of future investigations on the various aspects touched upon in the present study have also been indicated.

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MINING ENGINEERING

CREEP AND TIME-DEPENDENT STRENGTH OF ROCKS

Ravindra Nath Sup : *Dr. D. P. Singh*

Deformation and strength of rock are time-dependent. Therefore, a study of creep or time-dependent strain and time-dependent strength is necessary for designing structures in rocks which have to stand for a long time. A determination of long-term strength will enable a time-safe structure to be designed and a knowledge of creep characteristics and time-dependent strength will help in determining the stability and safe life of existing structures. The specific applications in mining are in the fields of design of pillars, stability of open-pit slopes, study and control of rock bursts and outbursts, design of large underground openings for storage of petroleum and nuclear wastes, stability of tunnel linings etc.

The long-term strength determination by direct method is very tedious and time-taking. Therefore, a quicker method based on short-term tests is required. The present study aims to assess the suitability of some of these short-term methods for this purpose. In addition, creep behaviour of some common Indian rocks have been studied during the course of this study. The investigations have been carried out mainly in uniaxial compression but some studies under triaxial conditions have also been made.

The rocks tested in the present investigations were Makrana marble, Chunar sandstone, Karanpura shale, Mandi rock salt, Jharia coal and Singrauli coal.

The thesis consists of five chapters in addition to references and appendices. The first chapter gives an introduction to the subject and brings out the importance and applicability of studies relating to creep and time-dependent strength of rocks.

The second chapter presents a review of literature and gives the state of present knowledge regarding time-dependent strain and time-dependent strength of rocks. The main topics covered in this chapter are creep curves, creep equations, rheological models, mathematical models, factors affecting creep, transverse creep, dilatancy and micro-

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fracturing, creep of rocks in situ, creep of failed rock, theories of rock creep, methods of determining long-term strength etc.

The third chapter deals with the experimental work. It describes the design and fabrication of equipment constructed for the application of constant load for the purpose of this study. Detailed drawings for the fabrication of level type and hydraulic type loading rigs, gas-hydraulic pressure intensifier and triaxial cells are given.

Experimental procedure for determination of apparent density, Shore hardness and longitudinal wave velocity are discussed Procedures for carrying out short and long-term tests in uniaxial and triaxial compression are described.

In the fourth chapter, a critical discussion of the results of the investigation is given and the conclusions and suggestions for future work are included in Chapter V.

In uniaxial compression tests carried out on the rocks tested in these investigations, modulus of elasticity and Poisson's ratio were found to be stress-dependent. Modulus of elasticity was found to be smaller at low stresses, constant in the middle stress region and again smaller near the failure stress. The Poisson's ratio was found to be small at low stresses, constant in the middle stress region and then increased continuously at higher stresses. The post-failure behaviour of all the rocks tested was of Class I type and all rocks except Mandi rock salt showed brittle characteristics. The most common mode of fracture was shear fracture (diagonal).

For Makrana marble and Chunar sandstone, the dilatancy method gave values of long-term strength close to those determined by direct method. Stress-strain method gave slightly higher values and log stress-log strain method gave lower values. For Mandi rock salt and Singrauli coal, meaningful results by direct method could not be obtained due to high scatter of data. It was found that the dilatancy method was the most reliable method provided lateral strain was measured over the whole circumference of the specimen by suitable circumferential strain encasing system. On the other hand, stress-strain method was the quickest.

In creep studies, both axial and lateral creep curves were found to follow the same pattern as far as different stages of creep were concerned. However, creep strains in lateral direction were found to be smaller than those in axial direction but the reverse was true for

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specimens loaded beyond their yield limit. In case of Makrana marble specimens loaded beyond their yield strength, a power curve of the form $\epsilon = at^b$ was found to fit the data up to steady-state stage. Secondary creep rate was found to increase with increase in stress for all rocks. While creep strains were smaller as compared to instantaneous strain in case of other rocks, Mandi rock salt showed quite large creep strains even at low stresses.

In triaxial compression tests the deviator stress at failure was found to increase with increase in confining pressure. The fractures took place in a diagonal (shear) manner and the angle of fracture was found to increase with increasing confining pressure. However, the ratio of predicted long-term strength to maximum strength was found to have a declining trend with increasing confining pressure. The long-term strength (deviator) of Chunar sandstone at a confining pressure of 9.8 MPa expressed as a percentage of average maximum deviator stress in quasi-static tests was found to be 71% which was close to that predicted by the stress-strain method. As a result of creep studies, it was found that the likelihood of creep fracture taking place in triaxial compression was much less as compared to that in uniaxial compression.

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PHARMACEUTICS

STUDIES ON FORMULATION & BIOAVAILABILITY OF PHARMACEUTICAL DOSAGE FORMS OF DRUGS : LORAZEPAM AND GLIBENCLAMIDE

Jagdish Singh Sup. : *Dr. S. B. Jayaswal*

The present studies are on the formulation and bioavailability of pharmaceutical dosage forms of drugs—lorazepam and glibenclamide.

Lorazepam is one of the newer benzodiazepines having utmost subtle advantages over its previously available congeners. It is a potent tranquilizer with sedative, hypnotic and anticonvulsant properties. It is practically insoluble in water and used in low dosage (1-10 mg daily).

Lorazepam tablet formulations containing directly compressible vehicles, e. g. Avicel pH-101, Emcompress, Anhydrous lactose and spray-dried lactose were studied for their physical properties, *in-vitro* dissolution rate and bioavailability in dogs. The highest dissolution rate and low disintegration time were exhibited by the tablets of batch DC-1, containing Avicel pH-101. The C_{max} value of the tablet formulations, did not differ significantly ($P > 0.05$) from that of solution except in the batch DC-2 containing Emcompress, in which it was found to be significantly lower ($P < 0.05$). However, the extent of bioavailability did not differ significantly ($P > 0.05$) in any of the above tablet formulations from that of the solution and, therefore, they were considered to be bioequivalent.

Nymcel is a recent development in the field of tablet disintegrating agents. Its presence in small percentage even causes the breakdown of the hardest tablets. Tablets containing 1, 3 and 5% W/W of Nymcel ZSB-10, ZSB-16 and ZSD-16 were evaluated for their *in-vitro* characteristics and *in-vivo* availability in dogs. Nymcel when used in the higher concentration exhibited higher *in-vitro* dissolution rate. Emcompress-based tablet formulations containing Nymcels were found to exhibit very low disintegration time. The C_{max} and F_{rel} values of the batch 3-ALZSB-10, 3-ALZSB-16, 3-ALZSD-16, 3-EmZSB-10, 3-EmZSB-16 and 3-EmZSD-16 were not significantly different ($P > 0.05$)

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from the solution. Hence, the tablets of these batches are considered to be bioequivalent to the solution.

The effect of diluents viz., lactose, dicalcium phosphate, tricalcium phosphate, calcium carbonate, calcium sulphate, mannitol and dextrose anhydrous were studied on the physical properties and *in-vitro* dissolution rate of lorazepam tablets and the result compared with the marketed Larpose tablets. The tablets of batch DL-1 containing lactose exhibited better physical properties and the highest *in-vitro* dissolution rate than the tablets of other batches. The dissolution rate of the drug in Larpose tablets was initially faster which slowed down later in comparison to the batch DL-1. At the same time the rate of bioavailability was slower and yet the extent was greater in the tablets of batch DL-1 when compared to Larpose tablets. Further, the Larpose tablets did not show any significantly different ($P > 0.05$) rate and extent of bioavailability in comparison to the solution; hence, are supposed to be bioequivalent to the oral solution.

The effect of different concentrations of the surfactants viz., sodium lauryl sulphate, sodium taurocholate, sodium tauroglycocholate and tween 80 on the physical properties, *in-vitro* dissolution rate, *in-vitro* permeation rate through rabbit jejunal sac and bioavailability in dogs of the lorazepam tablets were studied. All the surfactants in higher concentrations were found to increase the *in-vitro* dissolution and permeation rates yet the tablets of batch LSLS-5 containing sodium lauryl sulphate exhibited the highest *in-vitro* dissolution and permeation rates as well as rate and extent of bioavailability. The tablets of batch LSLS-5 also exhibited a significantly higher ($P < 0.01$) C_{max} and extent ($P < 0.05$) of bioavailability in comparison to the solution. Further, the effect of binders, e. g. PVP and PEG-6000 and disintegrant (Nymcel ZSB-16) in the sodium lauryl sulphate containing tablets were studied on the above parameters. The tablets containing PVP as binder and Nymcel ZSB-16 as disintegrant of the batch LPVPZ exhibited the best overall results. Thus, the tablets of the batch LPVPZ showed a significantly higher ($P < 0.01$) rate and the extent of bioavailability as that of the oral solution.

The lorazepam-PVP coprecipitate was prepared and included in the tablets formulation (batch LPVPC) which exhibited the slower rate but a greater extent of bioavailability in comparison to the solution.

The rectal administration of drugs as an alternate mode of treatment is of considerable importance. The suppositories were formulated

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from fatty (cocoa butter containing sodium lauryl sulphate and tween 80) and water soluble bases (from different compositions of PEGs) and studied for their physical properties, *in-vitro* permeation rate and bioavailability of the drug in dogs through rectal route. Suppositories of the batch CBLT-2 containing cocoa butter and 20% tween 80 was found to exhibit the highest *in-vitro* permeation rate and bioavailability among all the batches of cocoa butter suppositories. Similarly the suppositories of batch PEGL-3 were found to be the best among the batches of suppositories prepared from various compositions of PEGs.

The suppositories of batch PEGL-3 when compared with the batch CBLT-2, the former was found to exhibit the lesser drug content uniformity, yet the greater weight variation, dissolution/melting time, *in-vitro* permeation rate, the rate and extent of bioavailability than the latter. However, suppositories of all the batches containing PEGs exhibited better bioavailability than the cocoa butter suppositories without surfactants of the batch CBL-1.

The rectal absorption of lorazepam from the suppositories of all the batches was compared with the oral solution in dogs. The suppositories of all batches were found to have slower rate of bioavailability; however, the batch PEGL-3 exhibited the slower rate yet to the same extent ($P > 0.05$) of bioavailability as the oral solution in dogs.

Glibenclamide is a potent hypoglycaemic agent, used in the treatment of maturity onset diabetes mellitus. The drug is insoluble in water and about 45% of the oral dose is absorbed through G. I. T.

The different concentrations of surfactants viz., sodium lauryl sulphate, tween 80, cetrimide, sodium taurocholate, and sodium tauroglycocholate, and the drug-PVP coprecipitate were included in the tablet formulations and studied for their physical properties, *in-vitro* permeation rate through rabbit jejunal sac in 0.007 M-phosphate buffer (pH 7.4) and *in-vivo* lowering in BSL in the rabbits. All the surfactants in higher concentrations were found to increase the *in-vitro* permeation rate and *in-vivo* lowering in BSL except tablets containing sodium taurocholate, which showed the higher *in-vitro* permeation rate and *in-vivo* lowering in BSL in the batch GSTC-1 to GSTC-2 and beyond which a decrease in the pattern was observed. This might be due to the solubilization of drug in the surfactant micelles beyond the critical micelle concentration. However, the best results were obtained from the tablets of batch GT-4 containing tween 80, which showed markedly higher *in-vitro* permeation rate and *in-vivo* lowering in BSL than the tablets of all other batches and also the significantly more ($P < 0.01$) lowering in BSL than solution in the rabbits.

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Tablets containing drug-PVP coprecipitate initially did not influence the permeation rate and *in-vivo* BSL lowering in rabbits, but the extent of BSL lowering was higher than the marketed Daonil and plain tablets.

Further, the tablets of batches GSLS-4, GT-4 and Daonil were evaluated for their clinical effectiveness in the newly diagnosed and previously untreated patients of maturity onset diabetes mellitus. The tablets of GT-4 exhibited the highest rate and extent of lowering in BSL among all the batches studied. The tablets of batch GT-4 were also found to have significantly higher ($P<0.01$) rate and extent of lowering in BSL than the solution. The extent of bioavailability was 1.80 times greater than the oral solution. Our own formutation of the batch GT-4 was found to have nearly double the maximum lowering in half of the time and also two-fold greater extent of lowering in BSL in newly diagnosed and previously untreated patients of maturity onset diabetes mellitus when compared with Daonil tablets.

On the basis of these findings the following conclusions may be drawn :

1. The rate and extent of bioavailability of our formulated lorazepam tablets was found to have increased as compared to the oral solution.

2. The lorazepam suppositories were found to exhibit slower rate and yet the same extent of bioavailability through rectal route as that of oral solution. Thus, the lorazepam suppositories could be used as an alternate mode of treatment of the patients.

3. The glibenclamide tablets (Batch GT-4) exhibited two-fold effects with respect to Daonil tablets and 1.8 fold with respect to glibenclamide solution, on the extent of lowering in BSL in the patients suffering from maturity onset diabetes mellitus.

BIOPHARMACEUTICAL EVALUATION OF SOME SELECTED DOSAGE FORMS OF PHENYLBUTAZONE

J. K. Pandit Sup. : *Dr. K. D. Gode*

The ingredients selected to be combined with a drug, and the procedure by which a formulation is compounded have a marked effect on the bioavailability of a drug. The rate and extent of dissolution of a drug, present in solid dosage form, in the gastro-intestinal fluids

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depends in part upon the physico-chemical properties of the drug, and in part upon the manufacturing process adopted in the fabrication of the dosage form. Apart from these factors controlling the bioavailability of drug, the physiological condition of the patient also markedly influences drug availability.

Phenylbutazone, a drug used in the treatment of rheumatoid arthritis and related disorders, has an extremely low solubility and is strongly hydrophobic. These characteristics of the drug confer upon it a potential for bioavailability problems. Reports of erratic and incomplete bioavailability of some phenylbutazone products in the Canadian market have appeared in literature. It is also reported that the bioavailability of phenylbutazone is highly formulation dependent. Although this drug has a relatively abundant propensity of causing toxic reactions, it is still used in this country to a considerable extent. In fact, in some cases of severe arthritis refractory to other drugs, phenylbutazone (or oxyphenbutazone) seems to be the drug of choice, provided it does not produce severe toxic reactions.

Such factors as wettability, crystalline form, crystal size, drug-excipient interactions, and other physico-chemical properties that control the bioavailability of a drug have not been evaluated in depth in the case of phenylbutazone. Reports on the application of the various techniques to fabricate fast-release dosage forms and to achieve faster and more uniform blood levels of phenylbutazone are scanty.

The present study was undertaken to fabricate various fast-dissolving dosage forms through the preparation of microcrystalline and amorphous varieties, hydrophilization of the drug through various means, solid dispersions in polyethylene glycol of different molecular weights, and coprecipitates with water soluble carriers.

The following methods were adopted for the fabrication of the various dosage forms of phenylbutazone :

1. Microcrystalline varieties

   (a) The drug was dissolved in ethanol, polyethylene glycols 400 and 600, and propylene glycol, respectively, to obtain saturated solution. The solutions were added to ice-cold water, and the microcrystalline drug separated.

   (b) Phenylbutazone was dissolved in alcohol and chloroform and microcrystalline varieties obtained by flash evaporation of the solutions.

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(c) Another microcrystalline variety of this drug was obtained by pouring an alcoholic solution of phenylbutazone into a suspension of microcrystalline cellulose in water. The minuscular drug deposited onto the excipient was collected.

2. Two amorphous varieties of phenylbutazone were obtained, one by grinding with various proportions of microcrystalline cellulose, and the other by the simple expedient of subjecting molten phenylbutazone to shock cooling.

3. Two hydrophilized forms of phenylbutazone were obtained by treating the drug powder with a small amount of an aqueous solution of a cellulose derivative, and by crystallizing the drug from a solution of a biosurfactant.

4. Five phenylbutazone coprecipitate systems were prepared, using either polyvinylpyrrolidone (m. w. approximately 40,000), or mixtures of polyethylene glycol 4000 or 6000 with dextrose or mannitol.

5. Phenylbutazone-polyethylene glycol solid dispersion systems were prepared by melting polyethylene glycol 1000, 1500, 4000 or 6000, and adding the drug in different proportions, stirring to dissolve, and cooled rapidly.

For determining any possible interaction between phenylbutazone and various tabletting excipients the drug-excipient mixtures were prepared by two methods. The samples thus obtained were stored under different conditions, and then the physical and chemical interaction was assessed by thin layer chromatographic and spectrophotometric methods.

The various fast-release dosage forms were subjected to melting point, x-ray diffraction pattern, infra-red spectra, solubility and dissolution rate determinations. It was observed that the form obtained by flash evaporation from chloroformic solution of the drug is of a different crystalline form, as it gave a different melting point, i. r. spectrum and x-ray diffraction pattern than any other crystalline form of phenylbutazone hitherto reported. The sample obtained through the grinding of 40% drug-60% microcrystalline cellulose mixture was found to be amorphous, while there was no change in samples of other proportions. Similarly, the shock-cooled sample was also observed to be amorphous in nature. The nature of the i. r. spectra of the amorphous samples is different from the original drug.

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The highly hydrophobic nature of phenylbutazone is overcome in the hydrophilic dosage forms. Both the treated drug powders showed excellent wetting properties and optimum dissolution rates. The coprecipitate systems were subjected to dissolution rate testing in distilled water and pH 7.4 phosphate buffer. The coprecipitate of drug-polyvinyl pyrrolidone showed best results. The other coprecipitate systems, made with a mixture a polyethylene glycol 4000 and 6000 and dextrose or mannitol showed results that were better than that of the control. It was concluded that two different mechanisms are operative in bringing about higher-than control dissolution of the two sets of coprecipitates. It was observed in all cases that the dissolution fluid was supersaturated very quickly. The i. r. spectra and melting points of the solid material remaining in the dissolution vessel showed that in some of the microcrystalline and in both the amorphous varieties a transition took place from one crystalline form to the other, or from the amorphous to the crystalline form.

The solid-dispersion forms were found to release the drug in the dissolution fluid in a minuscular form at higher polymer concentrations, whereas at lower polymer concentrations the polymer was found to leach slowly from the drug-polymer agglomerates. The release of the minuscular form of the drug or the leaching of the polymer seem to be the mechanisms operating at different proportions of the drug and polymer resulting in higher dissolution rates. However, the increase in dissolution rate is not as large as in the case of some other drugs, when present in a solid dispersion form with polyethylene glycols of various molecular weights. It was evident from the dissolution rate studies that the dissolution rate of phenylbutazone increased linearly with the proportion and molecular weight of the polymer used.

Six tablet formulations were prepared, two being made by direct compression of the hydrophilized powder and the rest by wet granulation with starch paste or a solution of polyvinyl pyrrolidone (5% w/v in ethanol). A capsule formulation was made by encapsulating a mix of the drug and a lubricant in hard gelatin capsules. The tablets were stored at ambient temperature, and the capsules were stored at ambient temperature as well as at 50°C for 112 days. The tablets were subjected to d. t., hardness, friability and content uniformity tests initially and after six months of storage. The amount of decomposition product formed after storage was determined for both the dosage forms : negligible amount of decomposition products were detected in the capsules stored at 50°C, but no decomposition could be detected in the tablets or capsules stored at ambient temperature.

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The dissolution rate of the tablets was evaluated by three methods – the U. S. P. method using distilled water as the dissolution medium, and the Levy and Hayes's method using both distilled water and pH 7.4 phosphate buffer (0.2 molar). While the dissolution rates in distilled water were the same in both the methods, the dissolution rate was considerably higher in phosphate buffer. Some of the tablets failed to release the amount of phenylbutazone required in the U. S. P. XIX. There was a clear effect of the formulation on the release rate, especially when tested with distilled water as the dissolution medium.

Preliminary evaluation of the dosage forms, including two tablets, one marketed tablet, a control powder and eight fast-release dosage forms was done in mongrel dogs in a single-dose study. The maximum plasma drug concentration (C_{max}), time to C_{max} (T_{max}) and area under the plasma drug concentration-time curve (AUC) were chosen to compare the bioavailabilities of the dosage forms.

It was found that the drug-microcrystalline ground mixture gave an AUC that was twice that of the control powder. The same preparation, when given in a dose that was one-half that of the control powder, yielded an AUC that was about 86% of the control. In the tablets the one containing a wetting agent gave similar bioavailability to the control powder. Two of the microcrystalline varieties gave consistently higher AUCs that were 50% more than that of the control powder.

In the human volunteer studies, the rate and extent of absorption of four fabricated tablets, one marketed tablet, a lipid-containing dosage form (o/w emulsion), drug-microcrystalline cellulose ground mixture and a hydrophilized powder were compared with the rate and extent of absorption of a control powder (comprising microcrystalline powder) and drug solution in a single dose non-randomized cross-over study in five normal, healthy volunteers (all males). A large intersubject variation is observed in the plasma concentrations of individual subjects. As described previously, the C_{max}, T_{max}, AUC and Kel of the different dosage forms were compared as a measure of the bioavailability of the individual products.

The solution dosage form, as expected, gives the highest availability, closely followed by the emulsion Although the C_{max} of the solution is slightly lower than the emulsion, and the T_{max} is also longer, the bioavailability of the emulsion dosage form is similar to that of the solution. The elimination rate constants of these two forms are also identical.

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The marketed tablet, although showing a smaller C_{max} and longer T_{max}, has a similar bioavailability as the other tablets, viz., T-6, and T-4, and the dosage forms GM-4, T-3, S, T, and MC-3. Only T-1 has a longer T_{max}, being 8 hours, against 4 hours for T-6, T-4, and MC-3. It is very interesting and therapeutically important also to note the very short T_{max} for tablet T-3 (1 hr.), and also of the surfactant treated powder (2 hrs.).

Though the clinical importance of the fast-release dosage forms showing shorter T_{max} and higher C_{max} can only be verified by extensive clinical trials, it is certain that some of the dosage forms reported here are better than the innovator's product (Tablet Z), and merit further investigation in large groups of patients.

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APPLIED CHEMISTRY

STUDIES ON SOME ASPECTS OF KINETICS & MECHANISM OF CORROSION & INHIBITION OF ALUMINIUM ALLOYS IN NITIRIC ACID

Chanchal Chakrabarty

Sup : *Dr. C. V. Agarwal*
Co-Sup : *Dr. M. M. Singh*

Corrosion is a phenomenon of global interest. Study of corrosion is not only of scientific interest, but is important from the standpoint of nation's economy as well. The seriousness of corrosion problem has been realized for quite a long time and several attempts were made by various investigators to explain the mechanism of corrosion processes with a view to find methods for corrosion prevention. The metals used for different purposes vary in nature and consequently their mode of corrosion changes in specific environment. Since specific to a system, the study of mechanism of corrosion and inhibition requires a thorough consideration. In the present investigation an attempt to elucidate the mechanism of corrosion of aluminium alloys in nitric acid has been made. A number of organic additives have been used to inhibit the corrosion rate of aluminium alloys (1060, 1100 and 3003) in nitric acid and an attempt to provide an insight into the mechanism of inhibition has been made.

In the First chapter the significance of corrosion problem from both economical and technological points of view has been considered. The theories of corrosion with a greater emphasis on electrochemical theory of corrosion have been dealt at length in order to explain the problem and the mechanism. This chapter also includes a summary of the development of electrochemical theory of corrosion. The rate expression generally referred as Butler-Volmer equation for simple reaction has been mentioned and significance of the parameters (to mechanism of corrosion) used in the equation have been discussed. The diagnostic criteria for the determination of mechanism of electrode processes have been pointed out. The theory and application of potential step method to study the electrode processes have been mentioned. A summary of the progress made in understanding the mechanism of growth of film on metals has been made. The different current time relationships under potentiostatic conditions and how current time transients are analysed to identify the mechanism of growth of thin passivating films on metals have also been discussed.

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Numerous techniques employed to study the corrosion of metals and their alloys and to evaluate the parameters pertaining to corrosion studies have been mentioned. Finally, different methods adopted for corrosion prevention with special reference to the mode of action of inhibitors have been discussed.

Chapter II presents the experimental procedure and apparatus set-up used in the present investigations. Electrochemical studies were performed using potentiostatic steady state polarization, transient polarization and small amplitude cyclic voltametry techniques. Weight loss method was also employed to calculate the corrosion rate and inhibition efficiencies.

Chapter III of the thesis gives the results of the study of kinetics and mechanism of corrosion of aluminium alloys in nitric acid. The kinetics of corrosion of aluminium alloys (1060, 1100 and 3003) in nitric acid at its different concentrations have been studied at different temperatures (25°, 35° and 45°C). The rate of corrosion has been evaluated by different techniques, such as weight loss method, steady-state and instantaneous (transient polarization) Tafel extrapolation techniques near corrosion potential and to $i_f = 0$ respectively. Maximum corrosion rate was observed between concentrations of 20 and 40% of nitric acid. 1100 alloy was found to be least corrosion resistant in the nitric acid media at all the experimental temperatures followed by 3003 and 1060 alloy. The polarization behaviour of aluminium alloys in nitric acid system has been studied by potentiostatic methods. Cathodic polarization curves in different concentrations of the acid are almost parallel to each other but the nature of anodic polarization curves differ with concentration. In 20 and 40% acid concentration the curve exhibits active-passive behaviour whereas below 20% and above 40% (e. g. 60 and 70 %) the curves attain alomst a limiting stage. The critical current density values are found to increase with rise in temperature from 25° to 45°C. The breakdown potential increases with decrease in concentrations of the nitric acid. From the pathways of cathodic reactions postulated from known cathodic products and various kinetic parameters evaluated from the above mentioned studies, an attempt has been made to establish the mechanism of corrosion. It appeared from these studies that it is the rate of hydrogen ion discharge which controls the overall rate of corrosion of aluminium in nitric acid. The rate of growth of passive film has been found to be controlled by the rate of dissolution of aluminium as revealed from i-t transient curves.

Chapter IV deals with the inhibition efficiencies (I. Es.) afforded by different guanidine substituted compounds to the corrosion of the

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aluminium alloys, viz., 1060, 1100 and 3003 alloys in 20% nitric acid. In this concentration all the alloys used in the investigation exhibit maximum corrosion rate. This concentration of the acid was taken for the study in the forthcoming chapter also. The additives used in the investigation are as follows : Series I, 1-p-Methoxyphenyl-3-formamidinothiocarbamide, 1-p-Chlorophenyl-3-formamidinothiocarbamide, 1-m-Chlorophenyl-3-formamidinothiocarbamide and guanidine carbonate. Series II, 1-p-Chlorophenyl-3-p-tolylformamidinothiocarbamide, 1,3, di-p-tolyformamidinothiocarbamide, 1-m-tolyl-3-tolylformamidinothiocarbamide and 1-p-tolylguanidine carbonate. Except guanidine carbonate, which exhibits poor inhibitive performance, all the derivatives used were found to be effective inhibitors. The I. Es. of these compounds have been assessed at their different concentrations (50, 150, 250 and 500 ppm) in 20% nitric acid at 25°, 35° and 45°C. The I. Es. are found to be concentration dependent and exhibit maximum protective power at 500 ppm of the concentration, above which the increase in the I. Es. are marginal and therefore, experimental results have reported up to 500 ppm concentrations of the additives. The efficiencies of the compounds are found to increase with increase in temperature (i. e. from 25° to 45°C). Variation of percent inhibition efficiencies of the inhibitors in different concentrations of nitric acid solutions at constant concentration of 500 ppm of some effective inhibitors at 35°C has been studied. It is observed that maximum I. Es. are exhibited in 20% nitric acid solution and I. Es. of the additives are found to decrease above and below 20% acid concentration. A similar critical dependency has been observed in relation to the period of exposure. It is found that additives show maximum protective power at 24 hours of exposure after which the effectiveness is found to decrease gradually. Inhibitors used in the investigation are found to follow Langmuir adsorption isotherm equation, but the slope values deviate from the ideal value of unity. Most probable reasons for this deviation have been discussed. From the efficiency values obtained by weight loss data at different temperatures, heat of adsorption has been calculated. Electrode potential measurements in conjunction with the potentiostatic anodic and cathodic polarization studies were performed to provide some insight into the possible mechanism of inhibition. To support the views further small amplitude cyclic voltametry and surface studies have been appended. It appears from the above-mentioned studies, that compounds retard the rate of corrosion by acting predominantly on the local cathodes although partially effective on anodes as well.

In chapter V, investigations of the inhibitive action of benzoic acid and some ring substituted benzoic acid derivatives in relation to

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the corrosion of aluminium alloys (1060, 1100 and 3003) in 20% nitric acid at 35° and 45°C are given. The effects of the different groups (i. e. -OH, $-NO_2$ and $-NH_2$) were studied at different positions of the benzoic acid. The inhibitive efficiency (calculated from weight loss data), is found to be a function of the concentration of additives, and the position of the group in the molecule as well. For all the inhibitors investigated maximum I. E. is observed at the concentration of 0.5%. Above this concentration I. E. shows a decreasing trend, in all the cases. The inhibitors are found to be the most effective for 1060 alloy, followed by 1100 and 3003 alloys at both the experimental temperatures. An increase in temperature from 35° to 45°C invariably increased the inhibition efficiency afforded by the additives. Potentiostatic anodic and cathodic polarization studies reveal that the inhibitors are predominantly effective on local cathodes and effect on anodes are partial. With some reservations the increase in the cathodic Tafel slope values for different inhibitors are fairly in accordance with their inhibition efficiency. This clearly indicates that in the presence of the inhibitors the cathode is being polarized. To confirm the findings variation of current with time at constant applied cathodic and anodic potentials have been recorded. The anodic polarization studies show that there is a marked decrease in current density resulting in a shift in the inhibited curves towards lower current density region than the curve obtained in blank solution. The magnitude of the critical current density i_c values are found to decrease with increase in I. E. values. The passivation potential E_p and break-down potential E_b values have little relation with the inhibition efficiency and concentrations of the inhibitor. However, the change in the values of i_c, E_p and E_b are most pronounced at 0.5% concentration of the inhibitors. Further, effect of the additives on the polarization resistance have been investigated by small amplitude cyclic voltametry techniques. The results obtained from the electrochemical studies are fairly in harmony with those obtained from weight loss data which shows that the presence of these compounds retards the corrosion rate of these alloys in 20% nitric acid. O-amino and trihydroxy benzoic acids are found to be the most effective inhibitors amongst the investigated benzoic acid derivatives.

A consolidated list of journals and books consulted has been given at the end of the thesis to facilitate easy reference. A bibliography of the different books consulted during the preparation of the thesis has also been supplicated. Some of the research papers published/accepted have been reproduced in the form of reprints/preprints whichever are available as appendices I to VI.

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DEVELOPMENT OF EXTREME PRESSURE LUBRICANT ADDITIVES AND THEIR TRIBOLOGICAL STUDIES

Asok Mammen Sup. : *Dr. C. V. Agarwal*

Lubrication plays a vital role in our great and complex civilization. Every moving part of all the machines is subjected to friction and wear. Friction consumes and wastes energy and wear causes changes in dimensions and replacement of valuable parts of the machinery. The primary function of the lubricant is to reduce the coefficient of friction between the rubbing surfaces, thereby reducing the power requirement and wear by abstracting heat and thus increasing the overall mechanical efficiency in the various industrial and power plant machinery.

In hypoid gears, metal cutting and metal forming operations etc., the pressures developed at the contact areas are very high. Under such conditions it is very difficult to avoid metal-to-metal contact and surface temperature rise of over 1000^{0}C has been reported. Lubrication under such difficult conditions comes under the domain of Extreme Pressure Lubrication.

Under extreme pressures the boundary film of the fluid lubricant fails leading to deterioration of surface properties causing adhesion, seizure and excess wear. The friction and damage is minimised by using in conjunction with the lubricant certain organic additives containing active radicals. These are called Extreme Pressure Additives.

A survey of the relevant literature reveals that most of the earlier work in the field of extreme pressure lubricant additives has been done in a random manner. Most, if not all, the researches in the field have been undertaken in the laboratories of the leading petroleum companies. Their findings, of remotest practical utility, are kept as closely guarded secrets and the successful additives are covered under patents. Moreover, no work is on record, for correlating the effect of substituents on the efficiency.

At present India is spending crores of rupees for importing standard E. P. additives. Hence it is desirable to investigate the suitability of indigenous organic compounds which on blending will effectively substitute the costly imported formulations.

The work presented in this thesis was undertaken with this objective in mind, to carry out a systematic study of the synthesis and development of certain indigenous E. P. additives. The possibility of substituting costly alloy steel parts with less costly mild steel or other metallic parts was another objective of the work.

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Chapter 1 introduces the subject matter. Both metallic and non-metallic friction, the four types of wear, different types of lubrication viz., hydrodynamic, boundary, elasto-hydrodynamic and extreme pressure lubrications are dealt with in some detail. A brief review of the organic compounds used as extreme pressure additives and different testing machines used for the evaluation of these additives are presented followed by the brief objective of the work undertaken.

The next chapter, Chapter 2, describes the experimental procedure adopted. The details of preparation followed for the synthesis of the six series of organic compounds viz., isodithiobiurets, dithiobiurets, xanthates, S-alkylisothioamides. substituted S-benzylisothiocarbamides and 1-formamidino-2-S-benzyl-3-arylisothiocarbamides are described. In all 30 additives were synthesised in the laboratory. Next, the evaluation procedure of these organic compounds is outlined. Descrip- of the Seta-Shell Four ball Extreme Pressure Lubricant Testing Machine, test procedure adopted for the evaluation etc. are described in vivid detail. A brief account of the Scanning Electron Microscopy (SEM) technique used for the tribological studies of the ball surface is given. 0.5% wt/vol of the additive was mixed in the base lubricating oil 0.5 inch (12.7 mm) diameter steel bearing balls were used as the test specimen. Steel balls of 4 different compositions were used.

The third chapter is devoted to the results and discussion. The experimental results obtained with the different series of compounds are presented. The various parameters studied such as initial seizure load, welding load, scar diameter, coefficient of friction, contact pressure etc. are tabulated and are presented for each of the six series studied. The wear-scar diagrams, coefficient of friction-load curves, apparent contact pressure-load curves are also given. The efficiency of the synthesised additives are discussed in comparison with hexachloroethane or an imported additive. The technique of Scanning Electron Microscopy used for the tribological study of the ball surfaces is described later. SEM was used for confirming the effectiveness of the indigenous additives.

In the next chapter, Chapter 4, a mechanism for the extreme pressure action of the additives is proposed. The characteristic shapes of the wear-load curves are explained in terms of surface films formed.

In the last part, Chapter 5, the findings are summarised. Most effective additives from the different series are presented. Wherever possible, a possible explanation for the enhanced activity is given. The effect of additives on balls of different kinds has been discussed. The possibility of replacing the costly chromium steel alloy balls by less costly mild steel balls is suggested.

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Faculty of Indian Medicine

PRASUTI TANTRA

STUDIES ON CERTAIN INDIGENOUS ANTIFERTILITY DRUGS

Mukta Sinha Sup : *Dr. (Km.) P. V. Tewari*

Though population was not a problem in the past however desire of a man to avoid pregnancy inspite of enjoying carnal pleasure or at least desire of finishing the progeny of enemy was inherent from the time immemorial. One finds references for probable vasectomy or the use of drugs to make the enemy impotent, and certain mechanical obstructions into the female reproductive system for preventing conception in ATHARVA-VEDA. In BRIHADRANYAKA UPANISHADA a breath exercise i.e. PRANAYAMA is advised to be practised by couple during coitus to control their orgasm thus reducing the chance of pregnancy.

Inspite of elaborate scientific description of human reproductive physiology in the VRIHATTRAI of Ayurveda one does not come across any specific recipes to prevent the conception. However description of safe period, incomplete coitus etc. are described. Abstinence was practised in the form of four ASHRAMAS of the life, only 25 years of active reproductive life were allowed with various restrains on marital-relations. This was a natural regulator of family size. With the change in the society one finds references of the drugs to be used locally after the 11th Century. However recipes to be used orally find their mention only after 16th Century. Most of these recipes are not in common practice today.

While selecting the drugs for studying their action as antifertility agents, besides the recipes prescribed for the purpose certain other categories of the drugs also had to be looked into.

In selecting drugs for the present work, following points have been kept in mind :

1. The drugs prescribed for contraception
2. Substitute drugs

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3. Drugs replaced in different edition of books
4. Different drugs taken with one name
5. Folk-medicine
6. Different varieties of same plant

On the basis of previous description following drugs were selected to be studied in present work :

List of the drugs along with their specific parts studied and abbreviations used

Name	Latin Name	Parts used	Abbreviation
1. (a) Chaulai	Amaranthus spinosus	Leaves, Root, Seed, whole Plant	A.S.L., A.S.R., A.S.S., A.S.W.P.
(b) Chaulai Bhaji	Amaranthus polygamus	Root	A.P.R.
(c) Karela Bhaji	Amaranthus caudatus	Root	A.C.R.
(d) Chaulai	Amaranthus viridis	Root	A. V. R.
2. Cadamba	Anthocephalus cadamba	Flower, Root	AN. C. F., AN. C. R.
3. Bansa	Bambusa arundinacea	Root-stalk	B. A. R. S.
4. Chakram-arda	Cassia tora	Leaves, seed	C. T. L., C. T S.
5. Tekar	Clerodendrum phlomidis	Flower, Seed, Stembark, Leaves, Root	C. P. F., C. P. S. C. P. S. B., C. P. L. & C. P. R.
6. Chameli	Jasminum grandiflorum	Bud	J. G. B.
7. Karkotaki	Momordica dioica	Root-stalk	M. D. R. S.
8. Kadali (Kela)	Musa paradisiaca	Root	M. P. R.
9. Chitrak	Plumbago zeylanica	Root	P. Z. R.
10. Jayanti	Sesbania sesban	Flower, Seed, Leaves Root & Stem-bark	S.S.F., S.S.S., S. S. L., S.S.R., S. S. S. B.

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Study of antifertility activity of all these drugs has been conducted in two series. In the series I powdered drugs have been studied while in series II only those drugs showing encouraging results in series I have been worked out in the form of their alcoholic extracts. In both the series initially pilot study was done by feeding the drugs for 10 consecutive days. The method described by Khanna and Chowdhry (1968) was adopted, the only modification done in this experiment was in the feeding of drug as it was done for 10 days instead of 1 to 4 days in the pilot study, while in the study of mode of action the drugs were fed for 3 days during different phases of reproductive cycles.

After observing the result of pilot study further experiment was done to assess mode of action. This mode of action in both the series was assessed in three sets of experiments i. e. by feeding the drug for 3 consecutive days prior to oestrus, to know effect of the drugs on ovulation; by feeding the drug from 1 to 3 days of pregnancy to know the effect of drug on zygote or on implantation, and by giving the drug from 4th to 6th day of pregnancy to understand abortifacient properties. The drugs showing anti-ovulatory action were again studied for their oestrogenic, progestational and antiprogestational activity. In series II specific effect on copper acetate induced ovulation of rabbits and effect of drugs on isolated myometrium has also been seen.

In series I pilot study the powdered drugs were fed in the dose of 200 mgm/100 gm body weight to female rats, and laparotomy was done on 10th day of pregnancy. Though in A. S. W. P. and C. T. S. 7 animals and in B. A. R. S., C. T. L., C. P. S., M. D. R. S., M. P. R., P. Z. R. and S. S. S. 5 to 6 animals out of 10 were pregnant, however, the number of implantation was significantly less in comparison to distilled water ($P < 0.05$. < 0.05, < 0.01, < 0.001, < 0.05, < 0.05, < 0.05, < 0.05, < 0.01 respectively). In the group treated with A. S. R., C. P. F. & S. S. F. only 3 animals were pregnant with highly significant difference in implantations with distilled water ($p < 0.001$). In the pilot study on the basis of both these parameters together it is noted that A. S. R., C. P. F. and S. S. F. have shown good antifertility activity while weak antifertility action is noted in A. S. W. P., B. A. R. S., C. P. S., C. T. S., C. T. L., M. D. R. S., M. P. R., P. Z R. and S. S. S. Further study about mode of action of only these drugs was done.

The number of implantations in comparison to distilled water were significantly less in the groups treated with A. S. R., B. A. R. S., C. T. L., C. P. F., M. D. R. S., P. Z. R., S. S. F. and S. S. S. ($P = < 0.01$, < 0.05, < 0.01, < 0.01, < 0.05, < 0.05, < 0.01 and < 0.05 respectively).

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Maximum resorption of 82.35% was in A. S. R. & B. A. R. S. both followed by C. P. F., A. S. W. P. (both 54.29%), S. S. F. (53.85%) and C. T. L. (40.91%). Considering all these three parameters i. e. number of implantation/implantation present animal, number of litters delivered/ delivered rats and percentage of resorption together, it can be inferred that A S. R., B. A. R. S., C. T. L., C. P. F., M. D. R. S., P. Z. R., S. S. F. and S. S. S possess antifertility activity which probably is an antiovnlatory agents. The drugs with maximum antifertility activity is in A. S. R., C. P. F. & S. S. F.

In second set of experiment the drugs were fed for 3 consecutive days from 1st day of pregnancy. In this set of experiment none of the drugs tested seem to possess any specific antifertility activity, however very weak antifertility activity was seen in neoclinestrol, A. S. R. & C. P. F.

Third set of experiment was conducted to assess the property of the drugs as abortifacients, thus here the drugs were fed from 4th day of pregnancy for 3 consecutive days. In this study it was noted that number of implantation in comparison to distilled water was significantly less in the group treated with A. S. W. P. ($P = \angle 0.01$), C. P. S., M. P. R. S., M. P. R. & S. S. S. (P of all $= \angle 0.05$). Group ten and twelve receiving M. D. R. S. & P. Z. P. seem to be weak uterine stimulants because in both these drugs the abortion were noted and delivery of litters was much less in comparison to other drugs. The group five, six, thirteen and fourteen treated with B. A. R. S., C. T. L., S. S. F. & S. S. S. respectively also showed resorption of more than 40% implantations. Thus it, seems that these also possess very weak myometrial stimulant activity or else these might have acted in the same way as neoclinestrol.

Since majority of the drugs showed antifertility activity as antiovulatory agents, hence further studies of these drugs were done to assess the action like ovarian hormone. In this study of oestrogenic activity, method described by Lauson et al. (1939) with Dorfman's (1954) modification was used. These animals were fed all the test drugs in the dose of 200 mgm/100 gm body weight for 5 consecutive days. Two groups were given distilled water, neoclinestrol respectively. Vaginal opening, cornification of vaginal epithelium, weight of uterus with fluid and without fluid, and weight of ovaries (initial as well as weights/100 gm body weight of animal) were taken as parameters for assessing the oestrogenic activity. Maximum oestrogenic activity was seen in S.S.F. closely followed by C.P.F. & A.S.R. and then comes C.T.L In other drug

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also oestrogenic activity was noted but less in comparison to neoclinestrol and S.S.F. etc. test drugs.

Progestational and antiprogestational activity of all these test drugs was studied by the method described by Clauberg (1930d) and further modified by MCphail (1934), in the female immature rabbit weighing between 500-700 gms. On the basis of MCphail scale of progestational proliferation, it appears that none of the test drugs possess any progestational and antiprogestational activity.

C. P. F., A. S. R., S S. F., C. T. L., B. A. R. S. and S. S. S. showing promising antifertility activity in Series I were studied in Series II. The yield of alcoholic extract of all these drugs was 1/10 weight by weight. In the pilot study lowest dose used in this series was 20 mgm because 200 mgm/100 gm body weight powder was used in series I, however higher doses i. e. 60 and 100 mgm/100 gm body weight were also used in this series. In the pilot study conducted in same line as in series I. none of the drug in 20 mgm/100 gm body weight possess any antifertility activity. In the 60 mgm/100 mg body weight dose weak antifertility activitity was noted in C. P. F., A. S. R. and S. S. S. in highest dose i. e. 100 mgm/100 gm body weight all the test drugs showed antifertility activity maximum being in C. P. F., A. S. R. & S. S. F.

In subsequent study of mode of action the doses of the test drugs were rescheduled and given in the dose of 40, 60, 80, 100 mgm/100 gm body weight.

In the first set of experiment wherein the drugs were fed for 3 days before oestrus and number of animals conceiving as well as number of implantations were taken as parameters it was noted that C. P. F., A. S. R. and S. S. F. in the doses of 80 & 100 mgm/100 gm body weight have shown promising antifertility activity with better results in higher dose. Maximum antifertility activity is noted in C. P. F. in the dose of 100 mgm/100 gm body weight. In other three drugs i. e. C. T. L., B. A. R. S. and S. S. S. relatively weak antifertility activity is noted. These drugs probably acted as antiovulatory agents due to reasons explained under series I.

In second set of experiment the drugs were fed for 3 days from 1st day of pregnancy. In this set of experiment also implantation were resorbed in different doses of all the drugs, maximum being in A. S. R. and S. S. F. & C. T. L. Taking all these parameters together it appears that none of the drugs showed promising antifertility activity, however weak antifertility activity was noted in the animal treated with neocli-

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nestrol and C. P. F., A. S. R. and S. S. F. in the dose of 80 & 100 mgm/100 gm body weight.

In the third set of experiment the drugs were fed for 3 days from 4th day of pregnancy. In this experiment the number of animals delivering were much less in comparison to previous experiment. 1 to 2 animals in all the drug doses of 80 and 100 mgm/100 gm body weight had abortion as well as resorption which influenced considerably the number of litters delivering. On the basis of the incidence of abortion and also resorption etc., it can be said that C. P. F., C. T. L., B. A. R. S. and S. S. S. had shown weak antifertility activity due to their mild echolic effect.

Just like series I, here also oestrogenic and progestational activity etc. were done. For all these studies maximum effective dose i.e. 100 mgm/100 gm body weight was used. In oestrogenic activity study conducted in identical manner as in series I with similar parameters, it was seen that all the test drugs showed oestrogenic activity of varying degree maximum being in C. P. F. and A. S. R. followed by S. S. F. and B. A. R. S., S. S. S. showed lowest oestrogenic activity.

In this series besides above parameters histology of pituitary, ovary, thyroid and uterus was also done. Normally the exogenous oestrogen suppresses the pituitary and ovary, however when the exogenous oestrogen are administered to immature rats then they stimulate pituitary and ovary which was seen in present study. Initially with the administration of exogenous oestrogen thyroid becomes hypoactive with the rebound stimulation at a later stage. This hypoactivity of earlier stage was noted in this study.

To reconfirm the oestrogenic activity of these test drugs another set of experiment i. e. myometrial glycogen contents of rats uterus treated with these drugs were also studied with standard method.

Myometrial glycogen contents of all the groups significantly increased in comparison to distilled water. Maximum glycogen was noted in C. P. F., A S. R. & S. S. F. This study confirms that C. P. F., A. S. R. & S. S. F. possess good oestrogenic activity, however other drugs i. e. C T. L., B. A. R. S. & S. S. S. have also shown oestrogenic activity.

Progestational and antiprogestational effect of these test drugs in this series was also done in the same way as in series I. None of the drugs showed any progestational and antiprogestational activity.

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Earlier study showed that the drug acts like antiovulatory agent. To confirm the same the study of antiovulatory effect by the method described by Gupta et al. (1971), using 2% Copper acetate solution I/V as ovulation inducing agent was done. Visualization of corpora haemorrhagica after laparotomy was taken as a parameter. It was seen that all the drugs showed antiovulatory property maximum being in C. P. F. and A. S. R. followed by S. S. F. In other 3 drugs i. e. C. T. L., B. A. R. S. & S. S. S. ovulation inhibitory property was relatively less in comparison to other 3 drugs.

As mentioned earlier few animals in the third set of experiment of mode of action had abortion. To confirm the same action of all these 6 test drugs was studied on isolated rats uterus. All these drugs have shown stimulant action of varying degree maximum being in C. P. F. A. S. R. & S. S. F. The stimulant action of C. P. F., C. T. L. & B. A. R. S. was blocked by atropine-sulphate while other drugs showed direct stimulant action.

Present study shows that out of 13 drugs having 26 groups, 6 drugs C. P. F., A. S. R., S. S. F., C. T. L., B. A. R. S. and S. S. S. have shown promising antifertility activity. The antifertility activity is due to their oestrogenic action, which inhibits ovulation and thus prevents conception. All these drugs are also slightly uterine stimulant. Making an attempt to study mode of action of drugs from Ayurvedic points it becomes difficult to explain the action on the basis of specific properties of drugs i. e. their RASA, GUNA, VIRYA & VIPAKA. The drugs seem to be acting by their specific PRABHAVA.

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RASA SHASTRA

STUDIES ON VATSANABHA

Lal Bahadur Singh

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Vatsanabha is one of the most important drugs, used in Ayurveda. It bears several synonyms in Ayurvedic texts, like *Visa, Amrta, Ksveda, Nepala, Srngi, Madhura* etc. The vernacular names assigned to this drug are *Siugiavisa, Visa, Mithazahar, Teliavisa, Vachhanaga.* The various synonyms, as mentioned above, in fact represent the different *plant-species* of the genus *Aconitum* or the same species from different source places. *Aconite* is a poisonous plant growing all over the world and belongs to the family *Ranunculaceae.* The several species of Aconite, which grow in India have been extensively studied for their chemical composition and pharmacological action by the various groups of workers in Indian laboratory. Similarly intensive chemical and pharmacological investigation have been carried out on the different species of Aconite growing in different areas of the world. These investigations have established that although Aconite possess potent pharmacological actions such as analgesic, antipyretic and anti-inflammatory actions, they cannot be used for therapeutic purposes by internal administration due to severe cardio-toxic property. There are several methods prescribed in Ayurveda to prepare the Shodhit Vatsanabha and earlier study by the author in the Department of Ras-Shastra revealed there are two methods of shodhana. One comprising of macerating the Aconite root for seven days consecutively with cow's urine and replacing the overnight samples of macerate every day, washing the macerated drug with water, and drying under shade and removing the outer cortical layer from the drug thus treated; the other method involving treating the Aconite root with boiling milk for 12 hours, washing the milk-treated product and then peeling out the cortical layer from the dried material are both effective in reducing the toxicity without affecting the pharmacological property.

These two samples i. e. crude commercial Aconite and cow's urine *shodhit* Aconite have next been investigated for a comparative evaluation of their effects in pharmacological and biochemical studies.

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TABLE I

Sample No	Percentage of constituents alkaloids					
	Aconitine	Mesaconi-tine	Hypoaconi-tine	Benzoylaco-nitine	Benzoyleme-saconine	Benzoyl hypoconine
1. A. napellus (Crude)	0.003 ±0.0001	0.020 ±0.0012	0.004 ±0.0005	0.115 ±0.0469	0.006 ±0.0007	0.003 ±0.0001
2. A. Chasmanthum (Crude)	0.006 ±0.0002	0.017 ±0.0061	0.002 ±0.0005	0.078 ±0.0041	0.001 ±0.0009	0.001 ±0.0008
3. A. napellus (urine treated)	0.005 ±0.0003	0.007 ±0.0001	0.007 ±0.0001	0.041 ±0.0023	0.001 ±0.0003	0.009 ±0.0004
4. A. Chasmanthum (urine treated)	0.023 ±0.0005	0.025 ±0.0017	0.009 ±0.005	0.140 ±0.0011	0.004 ±0.0004	0.006 ±0.0007
5. A. napellus (Cow's milk treated)	0.024 ±0.0016	0.064 ±0.0072	0.029 ±0.005	0.603 ±0.0011	0.026 ±0.0004	0.119 ±0.0007
6. A. chasmanthum (Cow milk treated)	0.038 ±0.0034	0.091 ±0.0080	0.050 ±0.0052	0.276 ±0.0360	0.040 ±0.0012	0.074 ±0.0022

In the subsequent series of investigation, the shodhana of crude commercial sample has been done by treatment with urine, without isolating the constituent species.

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The fact brought out is that *shodhita* Aconite is much less toxic than the crude Aconite and further that the toxic actions are mainly manifested on the central nervous system and in cardiac activity. Studies have been undertaken to find out the effect of both crude and *shodhita* Aconite on brain neuro-humours including Acetylcholine-content and Histamine-content. Simultaneously, study has also been conducted on the glycogen-content in the cardiac muscle to verify if the cardiac toxic-effect is manifestation of stress and strain on myocardium. In addition to studying the glycogen content of cardiac muscle, the glycogen-content of liver tissue has also been estimated to see, if the drug affects the general metabolic pattern in the organism.

In the first set of investigation, where the individual species have been identified the pharmacognostic study of the commercial sample of Aconite, procured from the local market, shows that it is a mixture of the roots of the *species of Aconitum* i. e. *Aconitum napellus* (Indian species) and *Aconitum chasmenthum*, which have been sorted out and subjected to *shodhana* individually. The investigations of their chemical studies by H. P. L. C according to Hikino technique undertaken at the Pharmaceutical Institute, Tohoku University, Japan yielded the results indicated in Table I.

All the four samples on being analysed for total alkaloid and Aconitine contents revealed the results shown in Table II.

TABLE II

Showing the total alkaloid and Aconitine contents in extracts of crude & shodhit Aconite

	Crude	Shodhit
1. Total alkaloidal contents	*P. E. extract 5.4%* Alcoholic 2.73% extract	*P. E. extract 11.2%* Alcoholic 6.35% extract
2. Aconitine	*P. E. extract 2.71%* Alcoholic 6.342% extract	*P. E. extract 6.342%* Alcoholic 6.265% extract

The urine samples after first and second maceration in the process of *shodhana*, having shown the presence of alkaloids, have been analysed to estimate the percentage of alkaloids, which are as follows :- Sample No. 1 contained 0.04519% total alkaloid and Sample No. 2 contained 0.03816% total alkaloid.

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The experimental studies, which have been conducted with these samples of crude Aconite and shodhit Aconite, revealed that intraperitoneal administration of crude Aconite in dose of 50 mg/kg and shodhit Aconite in dose of 100 mg/kg has highly significant barbituret hypnosis potentiation effect. It is noted that the shodhit Aconite in the dose, as mentioned above, has a more pronounced effect than crude Aconite as evident from the sleeping time of the animals in the order of 49 ± 13.9284 mts. and 34 ± 4.8998 mts. with shodhit Aconite and crude Aconite respectively. This is quite significant in view of the fact that it was observed earlier by the author that the total alkaloidal content in shodhit Aconite is comparatively less than that present in crude Aconite.

The studies on the anti-convulsant effect of the two preparations i. e. crude Aconite and *shodhit* Aconite in albino rats against electric shock seizure has, however, shown that none of the prepartions can prevent the convulsion produced by electric shock in an intensity of 250 m A for 0.2 seconds. In the next set of investigation on pigeon for testing the emetic effect of both crude and *shodhit* Aconite which is one of the associated toxicity of Aconite preparations it has been observed that the crude Aconite did produce emesis in a dose of 7.9 mgm followed by respiratory distress, collapse and death 10 minutes after administration of the dose upto 350 mg, although with the gradual increase in the dose, irritation followed by sedation was perceptible. A dose of 350 mg of *shodhit* Aconite killed 50% of the experimental birds after 30 minutes but a dose beyond 350 mg proved to be lethal for all. This indicates that the process of *shodhana* has modified to a certain degree the action of the drug on vomitting centre located in medulla.

It was observed earlier that irregularity of the cardiac function caused by Aconite is not of cholinergic origin and to settle if the slowing of the heart rate preceded by increased cardiac activity might be due to over activity of heart under influence of Aconite which laterally would cause depletion of muscle glycogen, a study of the glycogen-content of heart muscle after administration of crude Aconite and *shodhit* Aconite has been undertaken in albino rats. It has been seen that, whereas crude Aconite dose not lower the glycogen content (55.2 mgm against 56.2 mgm/gm in control) to any significant extent, the shodhit Aconite causes a more or less significant depletion of cardiac muscle glycogen (42.8 mgm/gm as against 56.2 mgm/gm in control). In case of liver-glycogen, however, both crude and *shodhit* Aconite reduces the glycogen contents (12.8 mgm/gm tissue and 22.6

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mgm/gm tissue respectively against 74.7 mgm/gm tissue in control) and it is found that crude Aconite exerts a more powerful effect than *shodhit* Aconite.

Clinical Studies

The results of the experimental studies, as recorded in the previous section, show that *Vatsanabha* possess positive analgesic, antipyretic and anti-rheumatic effects and further that the cardio-toxic action of the crude drug as well as the toxic side-effects, like gastric irritation and stimulation of the vomiting centre, can be modified to a great extent by the process of *shodhana.* These amply justified the claim of Ayurveda regarding its therapeutics potentiality in relieving rheumatic pain and fever.

In view of the above, it has been thought worthwhile to study the effect of one of the reputed Aurvedic preparations *Kubjavinodarasa* containing Vatsanabha as a major constituent for treatment of *Amavata* in clinical cases of rheumatoid disorders. In order to further verify whether Vatsanabha contributes positive therapeutic value to this preparation, control study have been done with products containing all the ingredients of *Kubjavinodarasa* except Vatsanabha itself. As two other ingredients of the preparation *Kubjavinodarasa* e. g. *Hartala* (Arsenic tri-oxide) and *Jaipala* (Croton seeds) are classified under *Vishavarga* along with Vatsanabha, it was presumed that these may play some role in activating Vatsanabha in relieving fever and inflammatory conditions.

The clinical subjects comprised of 44 patients suffering from Rheumatoid conditions in the age group of 11 years to 60 years of both sexes. In admitting the cases for the study, diagnosis has been made first by Ayurvedic parameters and later confirmed by modern diagnostic methods as laid down by American-Rheumatism Association (1969). The patients were divided in three groups with 18 subjects in group I receiving the test drug *Kubjavinodarasa* (RAK_1), 10 subjects in group treated with modified *Kubjavinodarasa* (RAK_2), that is preparation without Vatsanabha and subjects in group III have been given modified Kubjavinodarasa (RAK_3), which contains Vatsanabha but without the other two toxic ingredients, *Haratala* and *Jaipala.*

The drugs have been administered in the following order to the individual groups of patients. (RAK_1) one capsule (250 mgm) T. D. S. with water for one month. RAK_2 one capsule (250 mgm) O. D. for five days followed by one capsule (250 mgm) B. D. for one week and and then one capsule (250 mgm) T. D. S. upto 1 month. RAK_3 one acpsule (250 mgm) T. D. S. for one month.

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The overall effect of the treatment in the three groups of patients, being treated with the three preparations based on relief of symptomatology of rheumatic conditions is summarised in Table III below.

TABLE III

Complaints	Mean values before & after treatment		
	RAK_1	RAK_2	RAK_3
Pain in joints	4.06±0.7947	3.6±0.5676	3.07±0.6325
	1.03±0.1873	2.9±0.1795	0.73±0.16
	t = 16.1655	t = 6.1281	t = 13.69
	p<0.001	p<0.001	p<0.001
Swelling	3.28±0.9984	3.0±0.8756	2.47±0.7550
	0.33±0.2363	2.1±0.2769	0.25±0.1887
	t = 12.513	t = 3.2503	t = 11.761
	p<0.001	p<0.001	p<0.001
Stiffness	2.94±0.8948	2.3±0 4977	2.06±1.612
	0.72±0.2109	1.75±0.1575	0.34±0.3153
	t = 10.5386	t = 3.492	t = 5.265
	p<0.001	p<0.01	p<0.001
Tenderness	2.94±0.1169	2.5±0.8433	2.93±0.7937
	0.47±0.1689	2.1±0.2667	0.28±0.20
	t = 14.635	t = 1.4987	t = 9.050
	p<0.001	p<0.05	p<0.001
Deformity	0.89±0.7823	1.55±0.798	0.93±0.6164
	0.25±0.1044	1.00±0.25	0.43±0.15
	t = 3.465	t = 2.20	t = 3.13
	p<0.01	p<0.05	p<0.01
Loss of function	2.67±1.2397	2.5±1.4230	2.87±0.6083
	1.04±0.2922	1.65±0.4499	0.3±0.150
	t = 8.465	t = 1.8893	t = 11.87
	p0<.001	p<0.05	p<0.001

In regard to the effects of drug on functional activity it has been observed that *Kubjavinodarasa* containing Aconite, *Haratala* and *Jaipala*

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has a highly significant effect on the pressing power of righthand 64 8 ± 3.2587 / 71.57 ± 1.2316 ($p<0.001$) and slightly significant effects on grip power of both hands without affecting the walking time. The same preparation without Vatsanabha i. e. RAK_2 shows no significant effect whatsoever on any of the functional activity but the preparation containing Vatsanabha alone without *Haratala* and *Jaipala* shows significant improvement in pressing power of both hands and grip power in both hand, although it does not have any effect on walking time. In regard to blood pictures slight improvement is noted in haemoglobin percentage with all the preparations but the total and differential leucocyte counts are rather uneffected except slight reduction in eosinophil-count with RAK_2 and RAK_3. This effects on eosinophil count is quite expected in case of RAK_2 as it contains *Haratala* but the positive response with KAK_3 without any response with RAK_1 is a bit confusing. However, it may be said from all accounts-pharmacological, biochemical and clinical studies that Vatsanabha or Aconite possesses analgesic, antipyretic and anti-inflammatory properties and further the process of *shodhana* successfully reduces the toxicity without affecting the therapeutic merit of the drug.

The chemical study has shown that the process of *shodhana* brings about some changes in the chemical characters of the alkaloids, which result in the formation of artifracts but these seem to retain the pharmacological activity. It has also been observed that Indian Aconite sold in the local market is an indiscriminate mixture of the biennial roots of the *Aconitum napellus* and *Aconitvm chasmanthum*. The percentage of alkaloidal constituents of the two have been found to be different.

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Faculty of Medicine

ANAESTHESIOLOGY

BLOOD LACTATE AND PYRUVATE AS INDICES OF ADEQUATE OXYGENATION

Dr. (Mrs.) Krishna Gupta Sup : *Dr. K. Pandey*

This work was planned to evaluate the relative merits of measuring glycolytic parameters (viz., lactate, pyruvate, L/P ratio and excess lactate) and acid-base and gas tension parameters in the assessment of the extent of tissue hypoxia in some important clinical situation which are of interest to the anaesthetist.

Reviews

Fairly extensive reviews of literature on the following topics have been included :

1. Chemistry of lactic and pyruvic acids.
2. Lactic acid metabolism and conditions associated with lactic acid acidosis.
3. Methodologies of lactate and pyruvate measurements.
4. Analysis of pH data.
5. Normal values of lactate, pyruvate, lactate/pyruvate ratio, excess lactate, pH, pO_2, pCO_2 and base excess in preoperative period.
6. Changes in lactate, pyruvate, L/P ratio, excess lactate, pH, pO_2, pCO_2 and base excess during :
   i. Shock.
   ii. Hyperventilation.
   iii. Tourniquet ischaemia.
   iv. Bain circuit anaesthesia.

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v. Ether and halothane anaesthesia, and

vi. Spinal analgesia.

7. Cerebrospinal fluid formation and variations in CSF composition.

Measurements

1. Normal values of lactate, pyruvate, L/P ratio, excess lactate, pH, pO_2, pCO_2 and base excess in

   (a) arterial blood,

   (b) venous blood, and

   (c) cerebrospinal fluid,

   in healthy subjects awaiting surgery for conditions not likely to cause metabolic upsets have been measured and presented. All values were within the normal range described in the literature.

2. A study of lactate, pyruvate, L/P ratio, excess lactate, pH, pO_2, pCO_2 and base excess in subjects having clearcut clinical signs of peripheral vascular failure has been carried out. The stated parameters were measured again after resuscitative measures and compared to those measured during shock.

3. Glycolytic parameters and gas tension and acid-base status in blood and/or CSF were also measured :

   (a) before and at various time intervals during hyperventilation with twice and thrice the predicted volume of minute ventilation in two groups of anaesthetised subjects (in some of these subjects CSF samples were also studied),

   (b) before anaesthesia, before tourniquet release and after tourniquet release in regional and systemic venous blood in subjects undergoing limb surgery under tourniquet ischaemia,

   (c) before anaesthesia and at different time intervals during anaesthesia in subjects breathing spontaneously through a Bain circuit with 140 ml/kg/min fresh gas flow. Some of these subjects were switched on to Magill circuit for 1/2 hour at the end and blood samples were collected at 1/2 hour on Magill circuit, and

   (d) before and at 45 min. after spinal analgesia and surgery.

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The results indicated that anaesthesia itself produced rise in lactate, L/P ratio and excess lactate. Over and above this, some rise (mostly significant) occurred due to hyperventilation and tourniquet ischaemia. Breathing through Bain circuit was productive of a greater rise in lactate, L/P ratio and excess lactate and switching on to Magill circuit mitigated this effect. Surgery under spinal anaesthesia was also associated with increased lactate, L/P ratio and excess lactate.

Measurements of pH, pO_2, pCO_2 and base excess did not provide a valuable guide to the extent of possible hypoxia under the various situations which were studied.

It is concluded that parameters of glycolytic metabolism in various body fluids should be measured as a matter of routine if a real assessment of the hypoxic component in various situations is desired.

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ANATOMY

STUDIES ON THE TERATOGENIC EFFECTS OF ACETALDEHYDE IN THE RAT

R. N. Sreenathan Sup. : *Dr. Shamer Singh*

It has long been apparent that congenital malformations in children are, like cancer in adults, the biggest challenge to medical science (Smithells, 1980). As Woolam, (1966) puts, "The main purpose of teratology are to find out why some babies enter the world from physical, mental or metabolic handicaps from which the majority of their contemporaries are free, and with the knowledge thus acquired, to remove or, at least, alleviate the effects of these conditions."

Drugs and their sinister allies like smoking and alcohol are becoming increasingly important in this direction. Damage to the fetus by alcohol is now considered the largest known health hazard by a noxious agent that is entirely preventable. The spectrum of anomalies associated with maternal inebriation is known as "fetal alcohol syndrome" (FAS).

Acetaldehyde (AcH), the proximal, toxic metabolite of ethnol has been recently implicated in FAS. But the experimental studies are scanty and none of them have convincingly domonstrated the malformations akin to those of FAS. There appears to be no systematic attempt to investigate the effect of this metabolite on growth, malformations and skeletogenesis. Further, their is no study on its effect on gestation, postnatal survival, growth and maturation, as these constitute important aspects of postnatal study in the light of modern concept of behavioural teratology. Often little attention is paid to fetal millieu, such as placenta, umbilical cord and amniotic fluid in teratologic investigations. There is no report on qualitative and quantitative changes in placenta following AcH treatment. So the present experimental study has been an attempt to evaluate these effects induced by AcH in rat fetuses including changes in fetal milieu.

Single and triple doses of AcH (Fluka, Schweiz) diluted in normal saline were injected intraperitoneally (ip) into 80 pregnant CF rats on days 10, 11 and 12 of gestation (Sperm positive = day 1). Fetuses

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were collected on day 21 by hysterotomy. Though, there were significant resorptions similar to those of FAS, the effects were not day or dose dependent and further they were not uniformly distributed among all litters.

In the second experiment, AcH was administered (ip—50, 75, 100 and 150 mg/kg) to pregnant rat from day 8 to 15 of gestation. The teratogenic effects on term fetuses, were similar but again, lethality and malformations were restricted to certain litters, clearly demonstrating that while certain mothers were highly susceptible, the others were not. The inter-litter variability and the malformations such as microcephaly, micrognathia, hydrocephaly etc. were very much in keeping with human FAS.

Following AcH administration (ip—50 mg/kg) from day 8 to 15 of gestation, the fetuses were collected along with the corresponding controls at 24 hour intervals from day 16-21. This chronological observation revealed malformations which could be grouped into two categories : Group I—malformations seen during 16-18 days of gestation but were not observed beyond day 19. Group II—malformations which appeared on different days of gestation but continued till term.

While malformations and resorptions were restricted to certain litters, intrauterine growth retardation (IUGR) was generally observed in all litters. The degree of retardation was assessed chronologically using different parameters i.e. body weight, crown rump length, tail length and transumbilical distance. All of these parameters, showed that the AcH treatment was positively associated with a highly significant degree of IUGR throughout the period of observation.

Groups of 30-35 living fetuses collected on different days (16-21) of gestation from mothers which received AcH (50 mg/kg) from day 8 to 15 of gestation were processed for alizarin red-S stain. Ossification was found to be delayed in bones of the extremeties, vertebrae and skull bones, The sternebrae were most affected, there were wavy and lumbar ribs, and sporadic missing of vertebral arches and bodies.

To circumvent the possible suspicion that the effects may be route specific, AcH was administered (75 and 200 mg/kg) intravenously from day 8 to 15 of gestation and fetuses were collected on day 21. Comparable results were observed, thus ruling out any such possibility.

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In the next experiment, ethanol was administered (ip—200 and 300 mg/kg) from day 8 to 15 of gestation and fetuses were collected at term. The findings were very much in common with those following AcH treatment. These results substantiated the view that probably the effects of ethanol are mediated through its metabolite AcH. All the above experiments had parallel pair-fed vehicle treated controls, which ruled out any extraneous variables as possible causative factors.

The quantitative changes in placentae were studied using Weibals point counting technique. The salient findings of this study were :

1. The largely prevailing opinion that "the placental weight is a good indicator of fetal weight", may not be tenable,
2. The real indicator of fetal growth is the volume of the labyrinthine zone where actual exchange takes place and the absolute number of labyrinthine cells which are responsible for such fetomaternal exchange.
3. There are structural alterations in the placenta from day 16 till term.
   (a) Day 17 is critical for structural alterations in placenta.
   (b) There is rapid growth of both basophils and labyrinthine cells between days 16 and 17.
   (c) There is steady conversion of basophils into labyrinthine cells from day 17 till term.
   (d) Labyrinthine cell population continues to increase till term which is in keeping with the rapid growth of fetus during this period.

Acetaldehyde and alcohol had induced identical placental changes. They induced qualitafive changes such as infarction, perivascular fibrosis, hyalinization and thickened placental barrier in the labyrinthine zone. Thickened decidua and acidophilic pools in basal zone were the other findings. Quantitative findings showed depletion of labyrinthine cells which was probably responsible for growth retardation.

Amniotic fluid weight showed inconsistent changes in certain groups, whereas it was significantly more in the prolonged i p treatment. Umbilical cord length was significantly shorter in all groups.

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Postnatal study following AcH treatment (ip-50 mg/kg) from day 8 to 15 of gestation revealed significant prolongation of gestation. The prolonged gestation resulted in the increased postnatal mortality and increased incidence of maternal cannibalism. Treated offsprings showed delay in achieving certain preweaning reflexes as compared to controls. The growth landmarks, such as, opening of pinna and eye, appearance of hair, descent of testes and vaginal potency were signifcantly delayed suggesting delay in maturation. The offsprings were followed upto postconception day (PC day) 90 for their survival and growth potential. Body weight, crown rump length, and patellocalcaneal length along with tail length were measured daily and the retardation of growth in the treated group was found to persist significantly ($P < 0.001$) upto PC day 90. The reduction in the body measurements were found to be relative to the reduction in body weight. The velocity curves of different parameters revealed that the growth peaks of different regions of the body in the treated group were generally shorter, delayed and disturbed when compared to the corresponding controls. Thus postnatal functional disorder and the irreversibility of AcH induced growth retardation was evident by the failure of normal growth.

Acetaldehyde, the principle metabolite of ethanol has been shown to induce most of the malformations similar to those associated with FAS when administered (free from ethanol) in rat. Since alcohol sould induce similar effects in the same strain of rat, this study strongly implicates AcH in the pathogenesis of FAS and further suggests that the AcH induced placental changes are probably responsible for the teratogenic manifestation like intrauterine growth retardation.

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BIOCHEMISTRY

STUDIES ON CEREBRAL CARBOHYDRATE AND LIPID METABOLISM IN DEVELOPING RAT DURING UNDERNUTRITION

Purnima Bhargava Sup. : *Dr. Raj Shanker*

Effect of undernutrition during brain growth spurt period of rat on cerebral carbohydrate and lipid metabolism was studied. In particular, pentose phosphate cycle (PPC) enzymes, gangliosides and their degrading enzyme were studied as representative aspects of carbohydrate and lipid metabolism. In addition, isocitrate dehydrogenase (ICDH) glutathione and ascorbic acid were also studied under the same conditions.

Rat pups were undernourished by restricting feeding time from 6th day of postnatal life. Half the pups of a litter were kept separated from mother 12 hours daily for 12 days. At 18 days age pups were sacrificed and their brains analysed.

Undernutrition in this manner resulted in pups of smaller body size and lower body weights. Brains and different brain regions were also of lower weight. Undernourished rat brain had less total as well as regional protein content. Among different brain regions, cerebellum was found to be maximally affected by undernutrition.

Cholesterol and galactolipid content of undernourished rat brain was significantly reduced. In contrast ganglioside content of whole brain as well as different brain regions was found to remain unaffected due to undernutrition in suckling period.

During course of development, pattern of ganglioside accretion in different brain regions was found to be more or less similar. Total ganglioside NANA content of spinal cord and whole brain increased steadily with age, while ganglioside concentration (expressed as NANA in μ g/g wet wt.) was found to be maximum around 10 days age and minimum at 7 days age in spinal cord and whole brain. All brain regions also showed peak value of ganglioside NANA concentration at 10 days age, except cerebellum where peak value was observed at 7 days age.

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Effect of undernutrition on percentagewise distribution of NANA in five major ganglioside species viz., G_{M1}, G_{D1a}, G_{D1b}, G_{T1} and G_{Q1} in different regions of rat CNS was studied. Ganglioside species of cerebral cortex did not show any change due to undernutrition at 18 days age but those of other brain regions and spinal cord showed diverse changes at the same age. Rehabilitation for 15 days, however, abolished all the effect.

G_{Q1} could not be detected in olfactory lobes where G_{D1a} was found to be the predominant species at 33 days age. At this age, G_{T1} showed highest concentration in spinal cord, pons-medulla, midbrain, hypothalamus and cerebellum, while G_{D1a} was observed to be maximum in cerebral cortex and rest of forebrain.

In undernourished brain, at 18 day age, G_{D1a} was found to be higher in pons-medulla, cerebellum and rest of forebrain, lower in hypothalamus and uneffected in midbrain. G_{T1} showed tendency for elevation in spinal cord and midbrain. G_{M1} was found to be significantly lower in pons-medulla, midbrain and rest of forebrain. G_{Q1} was detectable in undernourished midbrain but not in control midbrain and G_{Q1} level of hypothalamus showed highly significant elevation due to undernutrition.

Neuraminidase, which cleaves NANA residues from polysialoganglioside species, showed lower activity in spinal cord and all brain regions of undernourished rats at 18 days age. The activity came to normal level, after 15 days of rehabilitation, at 33 days age in all brain regions. Among all regions lowering of activity at 18 days age was most notable in spinal cord and hypothalamus.

Physiological significance of these changes, specially in hypothalamus, are discussed in the thesis.

Effect of undernutrition on enzymatic operation of PPC was also studied. During postnatal development, first two enzymes of PPC, glucose-6-phosphate dehydrogenase (G-6-PDH) and 6-phosphogluconate dehydrogenase (6-P-GDH) showed much higher activity in immature brain as compared to adult rat brain. A major peak

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of activity was observed around 10 days age in normal brain. Measurement of total enzyme activity of G-67-PDH or 6-P-GDH (after solubilization of particulate enzymes with Triton X-100) revealed only a smaller and broader peak at 10 days age in normal brain. Evidence was also found that at 15 days age some dialysable inhibitor of above two enzymes may be present in normal brain.

In undernourished rat brain, specific activity of G-6-PDH and 6-P-GDH was found to be much lower as compared to controls at 10 days age. But the activities at 18 days age were found to be significantly higher in undernourished brain. Activities, however, come to normal level in adult age, after rehabilitation of 15 days or one month. When total activity of G-6-PDH or 6-P-GDH was measured (after solubilization of particulate enzymes with Triton X-100) undernourished animal's brain showed only slightly higher activity of these enzymes at 18 days age. The results suggest change in binding of enzymes to particulate fraction in undernourished brain, as well as during development in control brain.

In contrast, another enzyme of PPC, which is non-oxidative in nature, i. e., transketolase showed to major peaks of activity during preweaning developmental period. First peak observed at 1 day age is very sharp and the other peak observed between 7-10 days age is broader. Also, the activity in undernourished brain at 18 days age was found to be significantly lower.

In addition, at 18 days age, all three forms of ICDH i. e., NAD^+ and $NADP^+$ linked mitochondrial as well as cytoplasmic enzymes show significantly elevated activity due to undernutrition of 12 days during suckling period.

The developmental changes in glutahione and asnorbic acid content of rat brain and effect of undernutrition on glutathione and ascorbic acid content of rat brain at 18 days age was also studied. During development in suckling period, GSH showed a minor peak at 6 days age and major peak around 13 days age with a lowest level around 10 days age. Due to undernutrition from 6th-17th days age, GSH level was found to be significantly lower in 18 days old undernourished rat brain. Deficit is, however, made up after a month of rehabilitation.

During course of preweaning development, total ascorbic acid also showed highest level at 6 days postnatal age. Undernutrition

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from 6th-17th days age resulted in significant elevation of total ascorbic acid content of undernourished brain at 18 days age. The higher level comes to normal after one month of rehabilitation. Significance of these changes with respect to protein synthesis rate and activity of some membrane bound enzymes is discussed in the thesis.

It is concluded from all the above results that :

1. In undernourished rat brain, profile ot ganglioside species is altered in different regions, at 18 days age. The effect is most pronounced in case of hypothalamus.
2. In undernourished rat brain, activity of the enzyme neuraminidase is lowered in different regions at 18 days age. The effect is most notable in case of hypothalamus.
3. Developmental pattern of oxidative enzymes of PPC is altered in undernourished rat brain; activities follow a more immature pattern of development; showing more immaturity of undernourished brain.
4. Activity of non-oxidative enzyme of PPC, transketolase is significantly lowered at 18 days age in undernourished brain.
5. All three forms of ICDH show higher activity in brain of 18 days old undernourished rats.
6. Observed alterations in levels of glutathione and ascorbic acid of undernourished brain can make it more vulnerable to peroxidative damage.

STRUCTURAL CHARACTERISTICS OF 50S AND 30S RIBOSOMES OF *E. coli*

Rajvashisth Tripathi alias Byasmuni Sup. : *Dr. D. P. Burma*

Chapter I : Introduction

E. coli ribosome which is involved in protein synthesis is a complex organelle composed of 3 RNA chains and 53 different proteins. Extensive work is being carried out in several laboratories to unravel the structure of the ribosome. The review of the literature has been presented in this chapter. It has, however, been confined to three different areas in which the present work has been carried out.

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Since the major work that has been presented in this thesis is concerned with the L7/L12 stalk region of 50S ribosome of *E. coli* (Strycharz *et. al.*, 1978), the information about this region has been mainly reviewed. Actually this is one of the most interesting areas in the ribosome in term of structure. The 3'-end of 16S RNA in 30S ribosome appears to be practically a dangling end without any protein being associated in the region. Whatever information is available regarding this dangling end has been presented since some information has also been obtained about this end from the present studies. Finally, the major structural information has been obtained by the technique of immunoelectronmicroscopy. This has also been summarised in the introductory chapter. Although the immunological approach adopted in this case did not yield much information about the structure of the ribosome yet it was of interest to review the most successful area with a new tool which holds a great promise.

Chapter II : Materials and methods

The sources of the various materials used in the thesis work have been mentioned in this chapter. Further, the various techniques used in the work have been described. The enzyme RNase I has been one of the major tools used in this laboratory in the elucidation of the structure of the ribosome, therefore its preparation as well as use in different assay systems has been elucidated. The preparation of 70S ribosome, its subunits (both radioactive as well as nonradioactive), naturally forms the important part of the description of the experimental procedures. Isolation of L7/L12 depleted 70S and 50S ribosomes, L7/L12 proteins, rRNAs etc. constitute the other part. In this connection the various techniques like polyacrylamide gel electrophoresis, affinity chromatography, density gradient centrifugation, isoelectrofocussing, immunological techniques etc. used for identification of proteins, nucleic acids etc. have been described. Spectrophotometric and spectrofluorometric methods used for the study of the binding of ethidium bromide to the ribosome and its subunits constitute the other important experimental approach and those have been briefly mentioned. Similarly immunological approach was one of the three aspects of the work, therefore immunological methods employed in the present work have also been briefly described.

Chapter III : Results and Discussion

The work presented in this thesis has been carried out in three different areas to have some information about the structure of *E. coli*

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ribosome and it has been presented in three different sections as described below.

Section 1. Structure of rRNA in the L7/L12 region of 50S ribosome

The main object of this work has been to show that there is structural alteration of rRNA in the L7/L12 stalk region (Strycharz *et al.*, 1978) on removal of L7/L12 proteins. This stalk region forms one of the important structural and functional domains of the large subunit.

It was originally observed that the 70S ribosome on treatment with alcohol in presence of 1M NH_4Cl which leads to the loss of L7/L12 proteins, became resistant to RNase I action. This preliminary observation led to the detailed investigations. Actually the treatment was carried out at two different temperatures, 0°C when L7/L12 are removed and at 37°C when L7/L12 as well as L10 are removed. The proteins that are released by such treatment have been characterised by polyacrylamide gel electrophoresis, isoelectrofocussing and ouchterlony immunodiffusion. RNAs were also isolated from the core particles and their intactness was established by gel electrophoresis as well as affinity chromatography through lysine-sepharose 4B column. L7/L12-depleted core particle could be separated from 50S ribosome by agarose-acrylamide composite gel electrophoresis and its sedimentation constant was found to be about 56S.

The core particles were tested in the RNase I assay system. RNase I is single-strand specific although it has strong affinity for double stranded RNAs and the tendency to become latent in contact with the ordered structural regions of RNA. Core particle of 50S ribosome depleted of L7/L12 proteins is degraded by RNase I at a considerably slower rate than the intact 50S ribosome. The normal rate is restored on incorporating L7/L12 proteins into the core particle. The capacity of the core particle to inhibit the RNase I—catalysed hydrolysis of poly (A) is also greater than that of the 50S ribosome. The L7/L12 as well as L10—depleted core particle, however, behaves in the reverse way. Its rate of degradation is slightly faster than that of 50S ribosome and its inhibitory capacity is also less. These results indicate that the removal of L7/L12 as well as L10 exposes portions of RNA chain which are single stranded whereas the removal of only L7/L12 leads to the folding of rRNA in that region and therefore resistance to the action of RNase I.

It has been observed by both spectrophotometric as well as spectrofluorometric methods that the binding of ethidium bromide to

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the L7/L12 depleted core particle is more than that to 50S ribosome and reverse is the situation with L7/L12 and L10-depleted core particle. The dye-binding data support the observations made with RNase I. It appears from these results that the region(s) of rRNA in the vicinity of L7/L12 stalk has less ordered structure which on removal of L7/L12 proteins, becomes more organised. Apparently the binding of L7/L12 proteins to the 50S core leads to the destabilization of the double-stranded regions of rRNA.

Section 2. Action of RNase I on the 30S ribosome of E. coli

It was shown in other laboratories as well as this laboratory that RNase I becomes latent in contact with 30S subunit of 70S ribosome of *E. coli.* This was extensively studied in this laboratory (Datta and Burma, 1972). It was shown that the 30S ribosome is not degraded at all if Mg^{++} is present at a concentration greater than 1 mM. However, careful studies by spectrophotometric and density gradient centrifugation as done in the present work have shown that there is partial breakdown even in presence of high concentration of Mg^{++}. A simple alcohol precipitation method was developed to follow this quantitatively with the help of ^{32}P-labelled ribosomes. It was shown that the degradation was dependent on the concentration of Mg^{++} and the amount of enzyme but beyond certain limits these two have no effect at all. These results clearly indicated that there was partial breakdown of rRNA although that did not affect much the mobility of 30S ribosome through polyacrylamide gel. Eventually RNA was isolated from the 30S ribosome following the treatment with RNase I. The core RNA was found to move slightly faster than 16S RNA under both native and denaturing conditions. In this respect the core RNA behaved like 16S RNA which has been deprived of its 3′ dangling end by treatment with colicin E3. It was therefore suspected that the 3′-end which is not normally associated with any protein is the preferred site of attack by RNase I. One-dimensional high voltage electrophoresis of T1 digest of this RNA yielded slightly different pattern from that of 16S RNA indicating that that there was no extensive damage done to 16S RNA by RNase I treatment of 30S ribosome under the condition mentioned above. RNase I-treated 30S ribosome was found to be capable of associating with 50S ribosome in the normal way. Further, the core RNA derived from 16S RNA was capable of forming 30S particle with the total 30S ribosomal proteins added to it under reconstitution condi-

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tion. These observations indicate that no extensive damage is done to 30S ribosome by RNase I except that a considerable length of the 3′ dangling end of 16S RNA which is relatively accessible to the enzyme, is removed.

Section 3. Immunological approaches

The third approach towards the understanding of the structure of *E. coli* ribosome was with the help of immunological methods. Actually antibodies were raised in rabbit against intact 70S ribosome as well as its subunits with the expectation that these antibodies will prove very efficient in the immuno-precipitation of the intact ribosomes. However, this was found not to be quite true. One of the most important observations made in this connection is the fact that the immunoprecipitation of the ribosome and its subunits was very much dependent on the concentration of Mg^{++}. At low Mg^{++} concentration the precipitation was rather less. Efficient precipitation was obtained at high Mg^{++} concentrations. This was, however, not true when antibody against single protein, L7/L12, was used for the same purpose. Although the precipitation was only 50 per cent it was completely independent of Mg^{++} concentration showing that very little structural alteration is induced in this region by Mg^{++}.

Even in presence of high Mg^{++} concentration 30S ribosome is not as efficiently precipitated as 70S and 53S ribosomes with their respective antibodies. This may be due to structural characteristics of the two subunits. Ribosomal proteins are also inefficiently precipitated by the antibodies raised against ribosomes. Further, L7/L12-depleted 70S and 50S ribosomes are somewhat less efficiently precipitated with their respective antibodies, in comparison with intact 70S and 50S ribosomes. Apparently, L7/L12 proteins being located in the stalk region are readily accessible for reaction with the antibody. Finally, the comparatively inefficient precipitation of 30S ribosome was investigated by ultracentrifugation method. Somewhat less antibody had to be used to avoid precipitation. The formation of dimers and higher polymers was detected by such method and the formation of soluble complex did not interfere with the quantitative measurement. The analysis of the data showed that 70S and 50S ribosomes are reasonably efficient in the formation of immuno-complexes while it was not true for the smaller subunit. These data also indicated the differences in the structural organisation of the two ribosomal subunits so far as the interaction with the antibodies is concerned.

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Chapter IV : General Discussion

The results presented and discussed in three sections (Chapter III) have been rediscussed here in a general way to focus upon the implications of these studies. The major focus has been on the enzyme RNase I which has been extensively used in this laboratory to have information about the structure of mainly *E. coli* ribosome and to some extent other ribosomes (Burma, 1979 a, b; 1981; Burma *et. al.*, 1980). This enzyme has been helpful not only due to its specificity for single stranded RNAs but also due to strong affinity for ordered structures. In the present investigations as well this enzyme has been extremely useful. The most important conclusion that has been drawn from the action of RNase I on 50S ribosome is that rRNA in the stalk region is in unfolded state and is thus readily susceptible to the enzyme action. Removal of L7/L12 leads to the folding of the RNA in this region. Apparently L7/L12 destabilise the ordered structure in this region and help to build up the flexibility expected from the function of this region. The removal of L10 to which four copies of L7/L12 are anchored leads to entirely different situation. Useful information has also been obtained from the action of RNase I on the 30S subunit in presence of high Mg^{++} concentration. It was already known that in the 30S ribosome the 3'–end of 16S RNA is not associated with any protein (Santer and Santer, 1973; Woese *et al.* 1975; Teterina *et al.*, 1981). The present results support this strongly. This region is readily available to RNase I as well. Actually no other damage is inflicted by RNase I on any other region of 16S RNA in the 30S ribosome but in all probability the enzyme removes this dangling end. Although direct proof is still lacking circumstantial evidences corroborate this observation.

The binding of the intercalating dye, ethidium bromide, to the ribsome has also elicited some information about the alteration of the structure of L7/L12 region on removal of L7/L12 proteins. This tool supported the observation made with the help of RNase I. Thus the study of enzyme action and ethidium bromide binding can be exploited for structural studies and these are quite helpful as complementary techniques.

Finally, the immunological approaches have been of some use in the understanding of the differences in the overall structural organisation of the two ribosomal subunits. In this connection the effort

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of Mg^{++} on immunoprecipitation and the inefficient immunoprecipitation of 30S subunit are worth mentioning. Although the information obtained is preliminary in nature yet this type of approach has provided some clues which may turn out extremely helpful in further investigations of the structure of ribosome as well as understanding of its function.

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MICROBIOLOGY

EFFECT OF 5-HYDROXYTRYPTAMINE ON THE PATHOGENICITY OF *Entamoeba Histolytica*

Imtiaz Ahmad Sup. : *Dr. P. C. Sen*

Ten strains of *Entamoeba histolytica* isolated from faeces consisting of six non-dysenteric amoebic colitis (AC) and four asymptomatic cyst passers (ACP) were used in the present study. All the strains were grown and maintained by serial sub-cultures in Boeck and Drbohlav's medium. The pathogenicity of the strains were tested in weanling albino rats and quantitiated on the basis of caecal scoring according to Neal's criteria.

The average caecal score obtained with both the groups AC and ACP were not well correlated with the clinical severity of their source of isolation.

The non-dysenteric amoebic colitis isolated had average caecal score of 3.38 ± 0.86, while average caecal score of strains from asymptomatic cyst passers (ACP) was 2.28±0.93 which are just above the invasive level.

Effect of heat stress

This study was conducted with five strains of *E. histolytica*. The animals after inoculation of amoebae were divided into two groups. One group was subjected to 37°C daily for four hours and the other group which served as control was kept at room temperature. The caecal scores of the two groups was compared and it was observed that the animals subjected to heat stress had a significantly higher mean caecal score than the control group.

Effect of heat stress and cyproheptadine

In this study three strains of amoebae were used. The animals were divided into four groups. (A) kept at room temperature, (B) exposed to heat stress, (C) exposed to heat stress and administered cyproheptadine—a 5-HT receptor blocker, and (D) kept at room temperature and

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administered cyproheptadine. The average caecal score of animals in group (B) was higher than group (A) animals and that of group (D) animals lower than group (A) animals. The animals in group (C) showed mean caecal score lower than group (B) but higher than group (A). Thus although cyproheptadine decreased the enhanced virulence of *E. histolytica* under heat stress, but it did not completely nullify its effect.

Effect of PcPA

In this case the virulence of *E. histolytica* in hosts treated with PcPA-a 5-HT synthesis blocker, was compared with the untreated control animals. The virulence in all the three strains used in the study decreased significantly when the animals were treated with this drug.

Effect of 5-HT added to the cultures

In this part of the study seven strains of *E. histolytica* were grown in presence of different concentrations of 5-HT viz. 10 ηg, 20 ηg, 40 ηg, 80 ηg, 160 ηg, and 320 ηg per ml of overlay fluid of Boeck and Drbohlav's medium and two of these strains were also grown in presence of 640 ηg per ml. The replicates of all the strains showed increase in virulence when grown with 5-HT as compared to parallel replicates which were grown in absence of 5-HT. The virulence continued to increase and reached its maximum at 5-HT concentration of 80 ηg per ml after which there was a decline.

Effect of L-tryptophan added to the culture

In this experiment four strains of *E. histolytica* were grown in the presence of different concentrations of L-tryptophan —a 5-HT precursor viz. 1 mg/ml, 2 mg/ml and 4 mg/ml of overlay and their virulence tested in parallel with control cultures. The caecal scores of the cultures grown with L-tryptophan was not significantly different from their respective control cultures.

Effect of 5-H. I. A. A. added to the culture

Four strains of *E. histolytica*, in this study, were grown in the presence of different concentrations of 5-H. I. A. A—a metabolite of 5-HT. There was no significant difference in the mean caecal scores of the strains grown in presence of 5-H. I. A. A. from their replicates grown in parallel without 5-H. I. A. A.

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Effect of 5-HT on Con-A agglutinability

In this experiment the Con-A agglutinability of strains of *E. histolytica* grown with and without 5-HT was examined and compared. It was seen that MAI (Microscopic Aggregation Index) of all the strains which were grown with 5-HT was significantly higher than their replicates grown without 5-HT.

Effect of 5-HT on the total count of amoebae

This experiment was carried out with four strains to study the effect of 5-HT on the growth rate of *E. histolytica.* The mean total count of all the strains taken together was significantly higher when grown with 5-HT than in absence of 5-HT.

Effect of 5-HT on RNA synthesis

In this part of the study the effect of 5-HT on RNA synthesis was examined with six strains of *E. histolytica.* The parasite was exposed to 5-HT for different time periods viz 0', 5', 10', 20', 30', 60' and 120'. For every time period a parallel replicate in which time exposure to tritiated uridine was given without 5-HT, served as control.

The RNA synthesis was observed to increase from five minutes onward upto thirty minutes when in contact with 5-HT, after which it showed a rapid decline.

Based on the above experiments the following hypothesis is being proposed.

E. histolytica are potential pathogens for human beings. This potentiality when not stimulated, the parasite remains as a harmless commensal in the infected host. In situations where a host carrying the parasite in intestine is subjected to physical, psychological or physico-psychological stress in the form of fright, heat, acute starvation etc. there is higher synthesis of 5-HT in the enterochromaffin cells in the intestine. The enhanced level of peripheral 5-HT leaks into intestine from the enterochromaffin cells and comes in contact with hitherto harmless *E. histolytica.* The 5-Ht stimulates the rate of multiplication of the parasite as also enhances its virulence. As a result the parasite which remained as a commensal so far becomes invasive. Thus it is the host which in the ultimate analysis decides whether the protozoa in the intestine should remain dormant or become pathogen.

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It may be interesting to record here that increase in stress depresses cell mediated immunity also (Steven *et al.* 1981), thus providing the exalted parasite a freer ground to manifest its potentiality.

Thus stress of the host may affect on the one hand depression of protective mechanism, if any, afforded by the normal functioning cell mediated immunity and on the other hand increase the virulence of the *E. histolytica* via the neurotransmitter, 5–HT.

While postulating the above hypothesis the possibility of other host factors, that are influenced under a stressor, viz. histamine, acetylcholine, prolactin, prostaglandins, corticosteroids etc. also influencing the host parasite interrelation in amoebiasis may not be ruled out. These factors also need be studied regarding their effect on the pathogenicity of *E. histolytica.*

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ORTHOPAEDICS

BONE REGENERATION (IN LARGE OSTEOPERIOSTEAL GAPS)

Dr. Devinder Kumar Sup : *Dr. S. M. Tuli*

The topic of research in the present work is "Bone Regeneration", especially in healing of large segmental, circumferential osteoperiosteal gaps. An orthopaedic surgeon faces such an eventuality because of trauma, infections, tumours, diseases of bone, or even congenital absence or hypoplasia of bone. The autologous bone grafts though universally accepted as the best for healing of such gaps are not always successful, and quite often not practicable particularly in children. Thus there is a need for a substitute which should have a favourable biological behaviour as compared to autologous bone graft.

With this aim large circumferential osteoperiosteal gaps were created in the diaphysis of ulna of rabbit. The controls were, where (i) the gaps had been left unfilled with any material, or (ii) the gaps were filled with spongostan (hemostatic gelatin sponge, Ferrosan, Malmo, Sweden), (iii) the fresh autologous 'reversed graft' were replaced back in the gap. The work is essentially a continuation of work done in the Bone Research Laboratory of this Institute (Tuli and colleagues, 1978, 1979, 1981) using decalcified bone matrix in healing of osteoperiosteal gaps.

The work was started using fully decalcified allogenic bone matrix grafts for healing of large diaphyseal gaps (average 3.5 cm in the total average length of 7 cm of rabbit ulna). Results were very encouraging. However, we thought that partial decalcification of allografts might provide a stabilising factor because of its mechanical strength. The results were very gratifying and we concluded that undemineralised core of partially decalcified allografts acted as internal splint while demineralised core provided ready penetrability for creeping substitution. The mechanical stability, and physiological stress and strains on such a graft, probably enhanced early vascularisation and early 'neo-osteogenesis'.

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We further decided to study the effect of non-invasive ultrasound on partially decalcified allogenic bone grafts used for healing of large osteoperiosteal defects. We concluded that ultrasound in the schedules used by us led to increased vascularity and cellularity in the graft and resulted in enhanced neo-osteogenesis (appositional as well as substitutional). We briefly reviewed the effects of ultrasound on bone and neo-osteogenesis.

Next we thought of testing xenogenic bone which was defatted, partially decalcified and composited with autologous marrow (to add osteogenetic as well as osteoinductive factors). We used human bones, and guinea-pig bones, thus prepared and composited, to heal large osteoperiosteal gaps (3 cm) in rabbit ulna. The results were very encouraging as compared to previous published works. We concluded that predifferentiated osteoblasts in the autologous marrow were responsible for early phase osteogenesis. While, osteoinduction occurred because of both autologous marrow (like intrinsic medullary osteoinduction, and defatted, decalcified xenogenic bone matrix (probably provided extrinsic osteoinductive factor). Defattening removed the fatty debris *in vitro*, the work which otherwise would have to be done by the host, thus, reducing its work load.

The diaphyso-epiphyseal (articular ends) resections and their reconstructions remain an unsolved problem inspite of extensive clinical trials since the beginning of this century. In our experimental model, diaphyso-epiphyseal segments of radius (distal 1/4th), of rabbits were partially decalcified (for 4-6 hours), preserved in 70% ethanol, and were then used to reconstruct diaphyso-epiphyseal resections in distal radius (1–1.5 cm). We concluded that osseous part of the graft provided osteoinductive factor and osteosynthesis occurred in all the 14 animals; varying degree of articular cartilage regeneration was also observed in 12/14 animals. The integrity of the 'tide mark' was generally well respected in these osteoarticular grafts, by subchondral vascularity. We further concluded that depending upon local determinant factors of the recepient area, articular cartilage, probably, provided a cartilage inductive factors (CIF).

Fascinated by the reports of Urist et al. (1979), Takaoka et al (1980); and Hanamura et al (1980a, b) about the solubilization and isolation of BMP (bone morphogenetic protein), and their observation that thus solubilized and isolated BMP was osteoinductive in heterotopic sites, and that BMP was not species-specific, we decided to

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prepare and use solubilized and isolated BMP for healing of large osteoperiosteal gaps in rabbits. We used BMP isolated from human bones (xenogenic by non-enzymic technique of Hanamura et al (1980a), as well as one isolated from demineralised rabbit bones (allogenic, using non-enzymic technique of Takaoka et al 1980). We observed overall neo-osteogenesis (complete of partial bridging of gaps confirming with histological and tetracycline fluorscence studies, the evidence of new bone), with allogenic BMP in 90.9%; while with xenogesic BMP it was 75%. We further confirmed observations of other researchers that BMP was not species-specific. We concluded that solubilized and isolated BMP can be used to heal large osteoperiosteal gaps. We have shortly reviewed and discussed the factors that can influence the osteoinductivity of BMP, as well as the origin of inducible cells in the host.

Encouraged by remarkable success with partially decalcified allografts to heal segmental bone defects in experimental studies, we decided to use partially decalcified (6-36 hours) allogenic bone in humans in four phases. Firstly, in heterotopic sites to study its biological behaviour; secondly, in healing of non-unions and delayed unions; thirdly, in large osseous defects; fourthly, in healing of large segmental osteoperiosteal gaps. No untoward effects were noted in first phase while in the second phase the behaviour was almost as good as with autologous bone grafts. In third phase the result was very encouraging with almost complete incorporation of partially decalcified allogenic bone with the host bone as compared with the preserved bone (case B-1 in table 1). In fourth phase as well some cases gave very encouraging results (cases C-3, 4, 7 in table 1), three cases had gross infection (C-1, 2, 6 in table 1) while in one case (C-5 in table 1) the graft underwent resorption. Histological and tetracycline fluorescence studies confirmed the evidence of new bone formation, even in grossly infected cases where the graft had to be removed (C-2, 6). We suggested that this material in humans was osteoinductive, and with certain modifications in preservation and operative techniques, the results could be markedly improved.

A brief historical review of bone transplantation, current concepts of cellular dynamics of bone, and biology of osteoinduction have been outlined. Experimental and clinical aspects in relation to the present study have been briefly summarised, while certain known as well as hypothetical aspects have been briefly discussed.

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Faculty of Science

BIOCHEMISTRY

STUDIES ON THE EFFECT OF *Commiphora mukul* ON THYROID FUNCTION IN HUMAN AND E PERIMENTAL ANIMALS

Yamini Bhusan Tripathi Sup : *Dr. O. P. Malhotra*

Introduction

"*Guggulu*", the exudate of the plant *Commiphora mukul* is regularly used in Indian system of medicine (Ayurveda) for treatment of arthritis, obesity, hypercholesterolemia and hyperlipidemia along with its clinical manifestations including coronary heart disease. Its clinical use can now be justified on the basis of several scientific studies on laboratory animals in more recent times. The mechanism of its action is not fully understood. Clinical effect of this drug has been studied by several workers. The results are consistent with a suggestion that *guggulu* may have a thyroid stimulatory effect which is responsible for the observed clinical effects. The objective of the present investigation was to test this hypothesis by studying the effect of *guggulu* on human patients and laboratory animals (rats).

Clinical effects reported earlier have been confirmed. Specific tests have been carried out to study the effect of this drug on the thyroid function, both in human and in rats. A thyroid stimulatory factor has been isolated from the crude drug and characterised for its chemical structure. Effect of the isolated compound on rats has been compared with that of the crude drug. Experiments have also been carried out to identify the primary target of guggulu and the isolated compound.

A survey of relevant literature on guggulu and thyroid function is given in chapter I. Results on the effect of crude drug on human patients and rats are described in chapters II and III, respectively. Fractionation of the crude drug and chemical characterisation of the

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isolated thyroid stimulatory factor are described in chapter IV. The data on the effect of isolated compound on the thyroid function of rats are given in chapter V, which is followed by a discussion of the results (chapter VI). Methodology and the materials used are described in chapter VII.

Summary

Guggulu (dry exudate of an indigenous plant, *Commiphora mukul*) has been traditionally used in Indian system of medicine as an appetiser, carminative, antispasmodic, diaphoretic, antiobesity, antiarthritic etc. drug. Recently it has been reported to have anti-inflammatory, anti-rheumatic, anti-thrombotic, hypocholesterolemic and hypolipidemic properties. Latter properties have been suspected to be mediated by stimulation of thyroid by *guggulu*. In some animal experiments, it has been shown that petroleum ether-soluble fraction of *guggulu* possesses biological activity. The insoluble residue is not useful. The present study was undertaken to investigate the effect of *guggulu* on thyroid gland and was carried out in four phases.

The first phase involved study of the effect of *guggulu* on lipid profile and thyroid function in twenty five electrocardiogram proved patients of ischaemic heart disease. The trial was conducted under the close supervision of clinicians of the Banaras Hindu University hospital. In the lipid profile serum cholesterol, phospholipid, triglyceride and free fatty acids were assayed for each patient and the values compared with those obtained with normal healthy volunteers. For the assay of thyroid function ^{131}Iodine uptake by the thyroid and serum protein bound iodine (serum PBI) were used as parameters. These patients were put on treatment with crude *guggulu* (8 g per day) for one month, after which the above were repeated. Before treatment, above two thirds of the patients were identified to have sub-clinical hypothyroidism (lower values for thyroid function parameters); the rest showed normal thyroid function on above parameters, but all the patients had hyperlipidemia. Treatment with *guggulu* brought down serum lipid levels. Thyroid function was increased in all the patients bringing to normal values in patients with sub-clinical hypothyroidism.

In the second phase involving study on laboratory animals (rats) petroleum ether extract of *guggulu* (oleo gum resin of *Commiphora mukul*) was used (100 mg per 100 g body weight) instead of the crude drug. Seven different parameters representing direct and indirect monitors of the state of thyroid function were estimated. These were ^{131}Iodine uptake by the thyroid, peroxidase and protease activities of

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the thyroid gland, serum PBI, serum tetra-iodothyronine (T_4), serum tri-iodothyronine (T_3) and tissue oxygen uptake. All the parameters were significantly increased on treatment of rats with the petroleum extract of *guggulu*.

Oleo gum resin of *Commiphora mukul (guggulu)* was found to be a slow-acting drug. Thyroid protease activity was the first to register a significant increase (after four days). This was followed by increase in thyroid peroxidase activity, serum T_3, T_4, PBI and tissue oxygen uptake (after six days) and iodine uptake by the thyroid (after ten days). These results have clearly demonstrated the thyroid stimulatory action of guggulu. Significance of the sequence of effect of the drug has been discussed. Thyroid stimulatory effect of this drug has been further corroborated by histological examination of the thyroid gland isolated from the drug-treated rats.

A known thyroid inhibitor, carbimazole (ethyl 3-methyl-2-thioimidazoline 1-carboxylate), has been used to induce hypothyroidism in rats. Its effect has been studied on the above parameters. If the inhibitor is administered together with oleo gum resin of *Commiphora mukul (guggulu)* the inhibitory effect of carbimazole is effectively counteracted by the drug. Since it is known that carbimazole has a direct action on thyroid and indirectly raised TSH (the thyrotropic hormone synthesised and secreted by the pituitary) cannot counteract the effect of carbimazole, it has been concluded that *guggulu* acts directly on the thyroid, without mediation through any other gland.

In the third phase, guggulu was subjected to chemical fractionation (solvent extraction and repeated column chromatography) in order to isolate and characterise the thyroid stimulatory factor. At each step, all the fractions were tested for thyroid stimulatory activity (^{131}Iodine uptake by the thyroid and histological examination of the thyroid tissue) and only the active fractions were subjected to further fractionation. A single compound (designated G_2 here) was found to possess thyroid stimulatory activity. Its physico-chemical properties (mp, colour reactions, uv, IR, ^{1}H-NMR and mass-spectra) were found to be identical with those of 4, 17 (20)—trans-pregnandiene-3,16-dione (Z-guggulsterone) isolated earlier from the same source.

Fourth phase cgnsisted of studies on the effect of Z-guggulsterone on the thyroid function of normal and hypothyroid rats. The latter state was induced by pre-treatment with carbimazole. Z-guggulsterone exhibits all the thyroid stimulatory properties shown by the petroleum ether extract of *guggulu*. A comparison of the drug dose-response of

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Z-guggulsterone with that of the *guggulu* extract suggests that the *guggulu* contains an, as yet un-identified component which may be suppressing the effect of Z-guggulsterone. Further, Z-guggulsterone helps to overcome the hypothyroid state (induced by carbimazole).

Conclusions

The present studies have shown that :—

(1) *Guggulu* (exudate of *Commiphora mukul*) has a thyroid stimulatory effect, which may be the basis of hypocholesterolemic and hypolipidemic effects ;

(2) The thyroid stimulatory effect of *guggulu* is direct and not mediated through increased secretion of TSH by pituitary ;

(3) The thyroid stimulatory factor present is 4,17 (20)-trans-pregnandiene-3,16-dione (Z-guggulsterone).

(4) Crude guggulu contains several other components which requires detailed biological study separately.

NEUROHUMORAL STUDIES ON CERTAIN STRESS DISORDERS WITH SPECIAL REFERENCE TO GASTROINTESTINAL TRACT

Naheed Banu

Sup. : *Dr. K. N. Udupa*
Co-Sup : *Dr. O. P. Malhotra*

1. Stress plays an important role in causing and prolonging mental and physical illnesses. Exposure to any type of stress, leads to neuroendocrine, endocrine and metabolic changes in the organism. Under normal situations, all these responses act as defence mechanisms and help the organism to face the stressful situations more effectively. However, in case the organism fails to adapt to these conditions, the above mentioned responses may last long and functional disability of one or more organs may develop and may precipitate one or the other disorders commonly termed as stress disorders for e. g. peptic ulcer, ulcerative colitis, irritable colon syndrome, ischaemic heart diseases, diabetes and cancer etc.

2. In the present study, the circulating levels of acetylcholine (ACh), acetylcholinesterase (AChE), histamine, histaminase, cortisol, 5-Hydroxytryptamine (5-HT), Dopamine B-Hydroxylase (DBH), and monoamine oxidase (MAO) were estimated in various stress disorders such as gastric ulcer, duodenal ulcer, ulcerative colitis, irritable colon

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syndrome, amoebiasis, giardiasis, ascariasis and in the cancers of oesophagus, stomach, colon, liver, breast, gall-bladder, lymphoma abdomen, cancer stomach with secondary in liver, cancer gall-bladder with secondary in liver and appendicitis. These have been compared with the values obtained with normal controls of both the sexes. A follow-up study was also carried out in all these patients after treatment in terms of above mentioned parameters.

3. The RBC acetylcholine, and blood histamine levels were estimated by bioassay methods. The activities of plasma histaminase, MAO, DBH and RBC AChE were determined by spectrophotometric procedures, while the levels of plasma cortisol and 5-HT were measured by spectrofluorometer.

4. In normals, there is no statistically significant sex-wise difference in the levels of ACh, AChE, histamine, DBH, MAO, Cortisol and 5-HT. The observed levels were slightly higher in females, but the differerence was not statistically significant, while the activity of plasma histaminase was significantly higher in females.

5. The RBC AChE, plasma cortisol and 5-HT levels were significantly enhanced, while the activity of plasma MAO was significantly decreased in the patients of gastric ulcer as compared to controls. An insignificant increase was observed in the levels of blood histamine, RBC ACh, plasma histaminase and DBH. After one month of follow-up all the parameters reverted towards their corresponding control values while plasma cortisol remained insignificantly enhanced.

6. In the patients of duodenal ulcer the circulating ACh, histamine, histaminase, cortisol, 5-HT and MAO levels were significantly enhanced, while the activity of erythrocyte AChE was significantly decreased. The activity of plasma DBH remained unchanged. After one month of treatment, the levels of histamine and histaminase remained insignificantly higher than controls; but the other parameters reverted towards their corresponding control values.

7. The circulating levels of ACh, histamine, histaminase, cortisol and 5-HT were significantly enhanced in patients of ulcerative colitis, while no change was observed in the activities of RBC AChE, plasma DBH and MAO as compared to the controls. After one month of follow-up, all the levels though reverted towards their control values were still altered than their normal values, while at the second follow-up, after two months, all the above biochemical parameters were reverted towards their normal values.

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8. Significantly increased levels of RBC ACh, blood histamine, plasma histaminase, cortisol, 5-HT and DBH were observed in the patients of irritable colon syndrome as compared to controls. The levels of RBC AChE and plasma MAO were decreased. After one month of treatment, the above mentioned biochemical parameters though reverted towards control values but were still altered than their corresponding control values.

9. In the patients of amoebiasis the circulating ACh, histamine, histaminase, cortisol, 5-HT and DBH levels were enhanced while the activities of RBC AChE and plasma MAO were found decreased in comparison to controls. After one month of treatment all the parameters reverted towards their control values while the level of plasma histaminase was still insignificantly higher.

10. The circulating levels of ACh, histamine, cortisol and 5 HT were significantly enhanced while the activities of RBC AChE and plasma histaminase were decreased insignificantly in the patients of giardiasis. The activities of plasma DBH and MAO did not change than their control values. All the levels were found to have reverted towards their control values after one month of therapy.

11. In the patients of ascariasis the levels of RBC ACh, blood histamine, 5-HT, cortisol, DBH and MAO were increased while the activities of plasma histaminase and RBC AChE were found decreased. All these parameters reverted towards their corresponding control values after a months treatment.

12. A significant increase was observed in the circulating ACh, histamine, histaminase, cortisol and DBH levels in the patients of appendicitis, while the activities of plasma MAO and RBC AChE were insignificantly decreased. After two weeks of surgery, all these altered parameters were reverted towards their control values.

13. The levels of RBC ACh, plasma cortisol, 5-HT and blood histamine, plasma histaminase, were significantly enhanced in the patients of cancer oesophagus, stomach and colon. The levels of RBC ACh, plasma DBH and blood histamine were more pronounced in cancer stomach patients and the activity of plasma histaminase in cancer oesophagus and colon. The activities of RBC AChE and plasma MAO were significantly decreased in these cancer patients. Even one month after surgery and therapy, all these parameters remained significantly altered as compared to their control values, though a slight reversion was found towards the control levels.

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14. In the patients of cancer gall-bladder the circulating ACh, histamine, histaminase, cortisol, 5-HT, DBH and MAO levels were significantly enhanced while the activity of RBC AChE was significantly decreased. These levels did not revert to normal values after one month of surgery and remained enhanced.

15. Circulating levels of ACh, histamine, histaminase, cortisol, 5-HT and DBH were increased in the patients of cancer liver, while the plasma MAO and RBC AChE levels were decreased in these patients. These levels did not return towards normal values after one month of surgery and chemotherapy, though a minor reversion was seen.

16. In the patients of lymphoma abdomen the circulating levels of ACh, histamine, histaminase, cortisole and 5-HT were increased, while the activities of RBC AChE, plasma DBH and MAO were decreased. After one month of treatment all these levels did not revert towards normal values, though slight reversion was observed.

17. Circulating HCh, histamine, histaminase, 5-HT, DBH and cortisol levels were increased, while RBC AChE and plasma MAO levels were decreased in the patients of breast cancer. After surgical treatment these levels were reverted towards control values except plasma histaminase and blood histamine levels remained slightly raised.

RBC ACh, blood histamine, plasma histaminase, DBH, cortisol and 5-HT levels were increased gradually and RBC AChE and plasma MAO levels were decreased gradually from first stage to fourth stage of breast cancer. Minimum changes were observed at first stage and maximum at fourth stage of the disease.

18. The circulating ACh, histamine, histaminase, cortisol, 5-HT and DBH levels were significantly enhanced, while the RBC AChE and plasma MAO levels were significantly reduced in the patients of cancer stomach with secondary in liver and cancer liver with secondary in gall bladder. These levels did not return towards control values after treatment (surgery, chemotherapy and radiotherapy). The condition of the patients also did not improve.

19. The significantly raised levels of ACh, histamine, 5-HT, cortisol, histaminase and decreased activity of AChE showed a tendency to return towards their normal values for those cancer patients who showed improvement (as in cancer breast). For the patients having severe cancer disease, as in the cases of metastatic cancer patients, however, these parameters did not exhibit any tendency, to revert towards the normal values.

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20. Circulating levels of ACh, AChE, histamine, histaminase, cortisol, 5-HT, DBH, MAO and the levels of ACh, AChE and 5-HE in the tissues of stomach, intestine and colon were determined in guinea pigs subsequent to histamine-induced duodenal ulcer and compared with normal controls in untreated animals. Effect of pre and post-treatment with an indigenous drug (Amalki) and in antacit stelabid have been evaluated in terms of these parameters in guinea pigs having histamine induced duodenal ulcer.

21. Following histamine injections to guinea pigs, the circulating levels of ACh, histamine, histaminase, DBH, cortisol, 5-HT and MAO were increased, whereas RBC AChE activity was decreased. The ACh and 5-HT contents of stomach, duodenum and intestine were increased while the activity of AChE was decreased in these tissues in the ulcerated guinea pigs. The changes were more pronounced in stomach and duodenal tissues than in the intestinal tissues.

22. In the stelabid (anticholinergic) and Amalki (indigenous drug) treated guinea pigs, the circulating levels of ACH, AChE, histamine, histaminase, cortisol, 5-HT, DBH and MAO returned towards control values. Effectiveness of the drugs was in the following order : Post treatment with Amalki—pre-treatment with Amalki –post-treatment with stelabid—pre-treatment with stelabid.

23. Circulating levels of ACh, AChE, histamine, histaminase, corticosterone, 5-HT, DBH, MAO and tissue levels of ACh, AChE, histamine and 5-HT were investigated in rats with acetic acid induced ulcerative colitis and compared with control values in untreated animals. Effect of pre and post-treatment with an indigenous drug Kutaj was evaluated in terms of these bio-chemical parameters in rats with acetic acid induced colitis.

24. The circulating levels of ACH, histamine, histaminase, corticosterone and 5-HT were increased, while no change was observed in the activities of RBC AChE, plasma DBH and MAO upto 7th day of induction. Concentrations of ACh, histamine and 5-HT were increased while the activity of AChE was decreased in the tissues of stomach, intestine and colon after acetic-acid induction.

25. The altered biochemical parameters in the rats with colitis reverted towards their control values after treatment with the indigenous drug Kutaj. The post treatment was more effective than in the pre-treatment in controlling these parameters in acetic acid treated rats.

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BOTANY

CYTOGENETICAL OBSERVATIONS ON SOME INDUCED AUTOPLOIDS AND INTERSPECIFIC HYBRIDS

Ravindra Nath Singh Sup. : *Dr. S. K. Roy*

The main object of this work has been to evaluate the performance of the induced polyploids from the point of view of their suitability for immediate use and with regard to the prospect which they offer for subsequent improvement by hybridization and selection in order to finally have tetraploid strains with improved floricultural values such as bigger flowers, better growth habit, longer duration of flowering and better keeping quality of the bloom. The autotetraploid ornamentals have established their superiority over the diploids from every point of view. They have relatively much bigger flowers than the diploids and their blooms show a change towards the deeper intensity of pigmentation. These characteristics make them more showy and attractive than the flowers of diploids. These tetraploids also, as is common to all induced polyploids, suffer from the major setback of low seed set. Meiosis in the pollen mother cells of the induced tetraploid ornamentals was of a relatively regular type : very few multivalents being formed. This is expected to ensure stability of the polyploid condition. *Petunia hybrida* (white) showed maximum univalents at diakinesis and metaphase. These univalents lagged at anaphase I and formed three plates at equator during metaphase II instead of two plates and ultimately formed six daughter nuclei. The other ornamentals occasionally formed five daughter nuclei. *Spironema fragrans* showed no seed formation though having healthy pollen grains. It would be necessary to improve the seed setting in these plants before a tetraploid variety could be released for general cultivation.

The application of polyploidization method was then tried on *Capsicum annuum*, an economically important spice crop to note if the economic value of the crop can be raised and the results included in the second chapter. Cytogenetical studies on these plants showed reduced growth but bigger leaves, flowers, stomata and pollen grains. The plants bore lesser but heavier fruits in the first-generation than the

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diploids. The yield was more in the second-generation in comparison to the first or third generation. One plant produced wrinkled fruits in the first-generation with very few seeds in them. Meiosis of colchiploids *Capsicum* showed different chromosome association in different generations. First generation showed maximum irregularities involving univalents, tetravalents, lagging chromosomes, bridges, fragments, micronuclei and anomalous tetrads. One plant showed marked difference in plant height, very large and leathery leaves and maximum univalents at diakinesis and metaphase. A few pollen mother cells showed all univalents at metaphase I. The bivalents included maximum rod type bivalents and ring bivalents were very less. The total absence of tri- and tetravalents was noteworthy. Instance of failure of pairing between homologous chromosomes at prophase and metaphase I has been ascribed to desynapsis in this species. Considerable chromosome lagging was found in anaphase I and II. Desynaptic colchiploid showed lagging chromosomes which formed small, supernumerary nuclei.

Chapter third, comprises of a discussion on the induced dodecaploid (12x) *Solanum nigrum* L. This is a high ploidy level at least for Solanaceae and the object was to note how such a level would behave cytogenetically. Contrary to what was anticipated meiosis of the induced polyploid turned out to be regular and the formation to tetrads normal.

Hybridization which is usually followed by the concomitant sterility is of undoubted value to the ornamental plants because they are usually not cultivated with a view to increase the yield as the seed crops but for values and qualities. In plants reproducing by seeds, partial sterility can be ignored especially where the seed output is high as in *Petunia* and in most members of Solanaceae. The genetic importance of the crosses then would lie on the evaluation of the extent of recombination and seggregation of the desirable alleles possible. This possibility of gene exchange can be realized in meiotic pairing and chiasma formation. The closeness of the relationship between the different taxa can be determined by crossability experiments. *P. axillaris* and *P. violacea* (Solanaceae) are herbaceous ornamentals of different morphological features. Interspecific cross between them constitutes the second part of the thesis. *P. axillaris* has lanceolate leaves, white flowers and long corolla tube while *P. violacea* possesses oblong leaves and rose red or violet flowers with short and broad corolla tube. Crosses in either direction attempted between them were

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successful. In the hybrids the characters of the female parents always dominated. The flower of *P. axillaris* x *violacea* were small and dull white and those of *P. violacea* x *axillaris*, small and pink. Both hybrids showed the occurrence of univalents during meiosis and contributed to the formation of laggards and ultimately micronuclei. Bridges were also encountered. Despite meiotic abnormalities, the F_1 hybrids showed good pollen stainability.

Solanum, the type genus of the family Solanaceae contains mainly two types of species in it, namely, those without and those with spines on the different parts of the body. There is discernible similarity between the phenotypes of the members of spinous *Solanum*, which is suggestive of their genetic relationships. And this can be tested by cytological analysis of the F_1 hybrids. The interest in studying the cytogenetical affinities of the species of spinous Solanums is accentuated from the point of view of their food, medicinal or ornamental values.

S. melongena L. is outstanding among these plants because of the inclusion in it numerous cultivars which range from being spinous to the ones without any trace of spines on them. Further, the economic value of the plant is great. The vegetable is grown all over India and at times it earns very good income to the growers. It is a fairly convenient vegetable under Indian culinary because it can be eaten, roasted, fried or mixed with any other vegetable to make an excellent combination of these. It is not very nutritive but nevertheless possesses some quantity of proteins, fat, carbohydrates, minerals and vitamin A, B and C.

An examination of the spectacular array of numerous varieties which are differentiated from one another mainly on the quantity, quality and colour of fruits has shown that the local and exotic varieties have very poor yield and that there are varieties which produce heavily but of which the taste of the fruits is unacceptable due to extreme bitterness. It is, therefore, clear that there is a need to explore the the possibilities of intervarietal or interspecific gene transfer by hybridization. The wild types possess attributes like hardiness and resistance to pest and disease which most of the high yielding varieties of brinjal lack. A knowledge on the cytogenetic relationships among the species would be helpful in evolving a satisfactory breeding programme for the improvement of this crop.

Thus the last part of the thesis includes the observations on the interspecific hybridization work between *S. melongena* var. *Dorli*,

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S. melongena var. *Round Black* and *S. surattense*. Two hybrids were obtained between *S. melongena* var. *Dorli* × *S. surattense* and *S. melongena* vor. *Dorli* × *S. melongena* var. *Round Black*. The objective of this study was to note the interspecific relationship among them on the basis of cytological study. Pollen sterility and yield was also calculated for the parents and hybrids. The F_1 hybrid *S. melongena* var. *Dorli* × *S. surattense* was possible only when the former was female parent. The fruits were obtained when the crosses were attempted between *S. melongena* var. *Round Black* × *S. melongena* var. *Dorli* but with sterile seeds. Some of these hybrids did not survive up to the flowering age. *S. melongena* var. *Round Black* × *S. surattense* was unsuccessful in either direction. Cytological studies showed univalents frequently at diakinesis and metaphase I in the hybrid plants but not so in their parents. The univalents were due to the absence of pairing between homologous chromosomes. Laggards varying from two to four and bridges were observed in the hybrids.

PHYSIOLOGICAL AND GENETICAL ASPECT OF COPPER TOXICITY IN THE CYANOBACTERIUM *Anacystis nidulans*

S. L. Gupta Sup. : *Dr. A. K. Kashyap*

The data incorporated in the present thesis relate to the physiological and genetical aspects of copper toxicity in the unicellular cyanobacterium *Anacystis nidulans* IU 625. A comparison has been made with one of the cyanophage resistant mutants designated as An/AS – 1. The results obtained during the present course of investigation may be summarized as follows :

(1) The mutant An/AS – 1 differed from *A. nidulans* parent in terms of slow growth rate (K = 0.41 as against 0.46 for the parent), altered content of photosynthetic pigments (low chl *a* and carotenoids but higher level of phycobilins), increased sensitivity to Cu^{2+}, and slow rate of nutrient (NO_3^{2-}, NO_2^-, NH_4^+, and PO_4^{2-}) uptake. The two strains were similar in cell size, photosynthesis (Hill activity) and mutation to streptomycin resistance.

(2) Cu^{2+} uptake studies revealed that Km for An/AS – 1 was lower (66.6 uM) than the parent (80.0 uM). Most of the Cu^{2+} taken up by the cell was transported across the cell membrane by 22 and

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33% were retained on the cell surface of An/AS – 1 and parent, respectively. The surface bound Cu^{2+} was recoverable by EDTA washing. The uptake of Cu^{2+} was not appreciably affected by the metabolic inhibitors like DCCD and FCCP either in light or in the dark, suggesting that Cu^{2+} uptake was not energy-dependent.

(3) Cu^{2+} affected the cell membrane permeability as evidenced by loss of K^+ ions from the cell which could be prevented by Ca^{2+} supplementation. Cell lethality was protected by ATP, Ca^{2+}, EDTA, PO_4^{2-}, amino acids (arginine, glutamine, aspartic acid, methionine, and cysteine) but not by ascorbate and glucose.

(4) Cu^{2+} inhibited the photoreduction of DCPIP (PS II activity) in spheroplast preparations from both the strains. The inhibitory action of Cu^{2+} was reversed by supplementation with Mn^{2+} but not with ascorbate. The result suggested that site of inhibition was either between Mn^{2+} and ascorbate donation sites or close to ascorbate donation site. Protection of the Hill activity by EDTA further suggested that Cu^{2+} interacted with the reaction center. As a result of inhibition of light reactions, level of methanol-insoluble carbohydrate was drastically affected than methanol-soluble carbohydrates, signifying that the former was mobilized to generate energy for cell metabolism.

(5) The uptake rate of nitrate decreased in short term (2 fold) as well as in long term (4 fold) experiments by treatment of *A. nidulans* (parent) with lethal concentrations of Cu^{2+} (5.0 uM). As a result of nitrate reduction, nitrite was released in the medium which was again taken up within 24 h by cell in absence of Cu^{+}. In contrast, rate of nitrite release was slow in Cu^{2+} treated cells and such cells failed to take up the released nitrite. This led to continued accumulation of nitrite in the medium. When nitrite was supplied, the uptake of nitrite was inhibited after 2 h of Cu^{2+} treatment. Under similar conditions, rate of ammonium uptake was decreased 3 fold in comparison to control by Cu^{2+} treatment. The results suggested that Cu^{2+} specifically inhibits at the level of nitrite assimilation. Similar conclusions were derived when An/AS – 1 was used in the investigation.

(6) Rate of phosphate uptake was higher in presence of Cu^{2+} than in its absence. When the level of phosphate declined in the medium, the cells were induced to form alkaline phosphatase (periplasmic protein) and acid phosphatase (cytoplasmic protein). However,

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the level of enzyme was low in presence of Cu^{2+} than in its absence suggesting that synthesis/activity was not completely abolished by Cu^{2+}.

(7) Cu^{2+} did not induce mutations in parent or An/AS-1 to streptomycin resistance. The drug resistance was induced efficiently by UV, MNNG, and acriflavine in both the strains. Based on induced mutation frequencies, it was observed that An/AS-was more stable than the parent. Under pre-treatment conditions, Cu^{2+} acted synergistically to a mutagen while under post-treatment condition, it suppressed mutation induction (antimutagenic). The frequencies of AS-1 resistants, streptomycine resistants and filamentous mutants were induced by Mn^{2+} although lethality was evident at higher concentrations (6×10^{-4}M) only.

(8) Mutants resistant and sensitive to Cu^{2+} were fortuitously isolated from colonies surviving after treatment of *A. nidulans* (parent) by Mn^{2+}. Majority of the mutants were slow growing and exhibited resistance to high molecular weight drugs (bacitracin, vancomycin, novobiocin, and actinomycin-D), alterations in methylene blue binding and sensitivity to sonic oscillation. The results are interpreted as cell surface alterations responsible for phenotypic behaviour of the mutants.

GENETIC STUDIES ON N≡N FIXATION BY BLUE-GREEN ALGA *Nostoc linckia*

Dhruv Kumar Sup. : *Dr. H. D. Kumar*

The data incorporated in the present thesis refer to the isolation of a filamentous, nitrogen-fixing and heterocystous cyanobacterium *Nostoc linckia* from rice paddies. Different clones of *N. linckia* were isolated from diverse habitats and were intercompared with respect to growth, pigment composition, nitrogen content, nitrogenase activity and UV-resistance character. A considerable range of variation was observed among these isolates. When their UV-resistant strains were pretreated with acridine orange and exposed to UV-irradiation, the resistance character was lost and the strains behaved like wild type. This finding points to the episomic nature of UV-resistance in *N. linckia*.

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Out of the above mentioned four clones of *N. linckia*, a photo-chemoheterotrophic and fast growing clone (B) was selected for further detailed experimentation.

Effects of various chemicals on growth, heterocyst frequency, and nitrogenase activity were seen and several mutants resistant to shikimic acid, propionate and amitrol were isolated at a tentative frequency of 1×10^{-5} to 1×10^{-6}; 1×10^{-4} to 1×10^{-5}, and 1×10^{-4} to 2.5×10^{-4}, respectively. These were intercompared with respect to growth behaviour in different inorganic nitrogen sources, heterocyst differentiation, nitrate reductase, nitrogenase and ammonia uptake activity.

All mutants as well as parent strains grew photoheterotrophically with or without DCMU in the dark when spiked with carbon sources. It is evident from our results that chemoheterotrophic growth was very slow in comparison to photoheterotrophic as well as autotrophic growth.

The effect of shikimate, a key intermediate metabolite in the biosynthesis of aromatic amino acids, was seen on 3-deoxy-d-arabino-heptulosonate-7-phosphate (DAHP) synthase. The observed 16.6 per cent DAHP synthase activity might be speculated to be due to shikimate-sensitive DAHP synthase. Shikimate also inhibited phycocyanin content of the alga, a characteristic of amino acid starvation.

Propionate alone amongst a series of fatty acids inhibited growth. This inhibitory effect of pripionate was overcome by equimolar concentration of acetate. The basis of possible propionate resistance mechanism might reside in the loss of *acetate kinase* activity of the organism. The inhibitory effect of amitrol may be attributed to the inhibition of *his* B enzyme activity. Resistance to amitrol indicates that this gene might have got detached from the *his* operator.

The revelation of exact chromosomal or extra-chromosomal location, and constitution of regulatory genes and for the understanding of the regulation of nitrogenase biosynthesis in cyanobacteria requires a large number of mutants impaired in their nitrogen metabolism. Six non-heterocystous and non-nitrogen-fixing mutant strains were isolated by nitrosoguanidine mutagenesis from a wild type population of *N. linckia* and were intercompared with respect to growth behaviour, chemoheterotrophic growth, nitrate reductase, nitrogenase; glutamine synthetase and ammonium uptake activities. The utilization of amino acids as a nitrogen source for these mutants was also studied.

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In general, there is no marked difference in growth behaviour of all the six mutants but comparatively *het⁻nif⁻*e is a first-growing and *het⁻nif⁻*a is a slow-growing mutant. Growth experiments were performed with different combined nitrogen and carbon sources. Ammonium uptake studies pertaining to wild type and mutant strains have indicated 12.5 per cent higher and 25 per cent lower uptake values for *het⁻nif⁻*a and *het⁻nif⁻*e mutants, respectively. Nitrate reductase activities (after 24 h) of the mutants *het⁻nif⁻*e and *het⁻nif⁻*c were highest and *het⁻nif⁻*a was lowest. The wild type showed lower activity than *het⁻nif⁻*e and *het⁻nif⁻*c.

Effects of various amino acids (glutamine, arginine, histidine, glutamic acid, aspartic acid and serine) on growth of wild type and mutant strains were studied. All mutant strains grew in the presence of arginine, glutamine, histidine and aspartic acid. However, serine and glutamic acid failed to support growth, except of *het⁻nif⁻*d which grew in the presence of 0.5 mM glutamic acid. The observed growth of non-heterocystous and non-nitrogen-fixing mutants of *N. linckia* in glutamine, arginine, histidine and aspartic acid supports the idea that these amino acids may be utilized as a nitrogen source. All the tested amino acids except glutamic acid, which is toxic, stimulated the growth of the wild type.

Complementation test was also performed to understand the inter-and intra-operon relationships. All mutants were found to be non-complementary with respect to nitrogenase and probably affect the same protein function.

The effects of vanadium and tungsten on growth and activity of two molybdoenzymes have been studied. While sodium vanadate stimulated better growth in comparison to tungstate and formed partially active nitrogenase, it did not affect nitrate reductase activity. The tungstate experiments indicate significant difference in the mode of action of V and Mo; this is apparent from the acetylene reduction (nitrogenase) activity of the organism.

The apparent lack of NH_4^+ induced repression of nitrogenase activity in 48 h old cultures suggests that ammonia is not the direct repressor of nitrogenase activity. Glutamine or some product of its metabolite is involved in nitrogenase regulation and the transcription of nitrogenase potein would be regulated at the level of cellular differentiation. This view is further supported by the disparity in the kinetic studies of repression of NH_4^+–effected nitrogenase and those of inhibitors of transcription (rifampicin) and translation (chloramphenicol).

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The overall results of these experiments show that on the one hand nitrogenase activity is inhibited by azaserine, glutamine, arginine, aspartic acid and glutamic acid, and on the other hand, it is not inhibited by α-methionine-DL-sulfoximine (MSO). While higher concentrations of sodium and molybdenum inhibit nitrogenase activity, the lower concentrations are required for the induction of nitrogenase in this organism. Glutamine synthetase activity is inhibited by MSO. The maximum nitrogenase activity was observed at 26 ± 1°C and pH 7.5.

Our observation on nitrogenase regulation suggests that the *nif* structural genes may represent the programmed sequential steps in heterocyst differentiation which in turn is necessary for the expression of the *nif* genes in this organism. We may conclude that in the heterocyst, nitrogenase biosynthesis regulation is probably indirect, as in bacreria.

Transmission electron microscopy (TEM) was employed to study the ultrastructural differences among the parent and mutant strains. There exist some notable differences in the ultrastructure of the parent cell and mutants cell.

CULTURAL AND CYTOLOGICAL STUDIES ON DINOFLAGELLATES

Jameel Ahmed Khan Sup. : *Dr. Y. S. R. K. Sarma*

The present investigation deals with the (i) morphological studies, (ii) cytological studies and (iii) physical as well as (iv) chemical parameters affecting the growth of eight taxa of freshwater Dinophyceae. They are : *Katodinium polyplasticum*, Popovsky, *Katodinium* sp., *Gymnodinium seruginosum* Stein, *Gymnodinium bohemicum* Fott, *Gymnodinium inversum* Nagaard var. *inversum*, *Gymnodinium paradoxum* Scillin, *Gymnodinium wawrikae*, Sciller and *Peridinium panardiforme* Lindem.

(i) Morphological Studies

Morphological and taxonomical aspects of these algal flagellates have been discussed on the basis of morphology of cells cultured under laboratory conditions; presence or absence of theca and the variation in the arrangement of plates; differentiation of structures such as girdle and sulcus which form the most characteristic features of these organisms; displacement of girdle; number, shape, size, colour

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and the arrangements of chromatophores and the knowledge of environmental variables causing variation in size within the species.

All the taxa, except *Gymnodinium paradoxum* Scilling are first reports of freshwater Dinophyceae from India.

(ii) Cytological Studies

The cytological observations recorded here confirm the unique karyological features of Dinophyceae described earlier by various workers.

The chromosome numbers estimated for all the eight taxa are the first report, except *Gymnodinium paradoxum*, from India as far as the author is aware.

The range of chromosomal count, found in various taxa varied from species to species, the lowest being in *Peridinium penardiforme* $n = 50 \pm 2$ and the highest being in *Gymnodinium bohemicum* $n = 254 \pm 4$. The highest chromosome number in *Gymnodinium behemicum* may be considered as the highest chromosome count except the exceptional counts of *Gymnodinium* sp. OBG 70, $n = @600$ (Shyam and Sarma, 1975). It has been concluded that the taxa with low chromosome numbers (as in *Peridinium penardiforme* $n = 50 \pm 2$) possess comparatively longer chromosomes (3.25 um to 7.05 um) while the taxa with highest chromosome numbers (as in *Gymnodinium bohemicum* $n = 254 \pm 4$) have shorter chromosome (0.5 um to 1.0 um).

On the basis of chromosome numbers, some taxonomic correlations have been made. The major role played by ploidy at generic as well as specific level has been discussed.

The vegetative reproduction of a single taxon *Katodinium polyplasticum* has been observed. It seems most probably that this alga reproduces vegetatively by multiple fission forming 16 nuclei, each mother cell ultimately producing 16 small daughter cells.

(iii) Effects of physical parameters on the growth

Effects of various physical parameters, viz., pH, temperature, quality of light, quantity of light, shaking and continuous light and darkness, on the growth of different algal taxa named earlier have been studied and the conditions for maximum growth for each taxon were determined.

The following conclusions have been drawn—

(a) The growth curves of all the taxa showed a typical pattern of growth showing 2-4 days of lag period, 4 to 14 day of typical

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exponential phase which continued upto 20 to 22 days following which decline phase ensues during 22nd to 30th day. Majority of algae attained maximum growth on 20th to 22nd day.

Most of the taxa revealed their generation time falling about 5 to 8 days. It was thus evident that all the taxa were of slow growing in nature in Carefoot basal medium.

(b) These freshwater dinoflagellates can tolerate temperatures ranging from 15°C to 30°C. Optimal temperatures for all the taxa determined. The three taxa viz. *Katodinium polyplasticum, Gymnodinium bohemicum* and *Gymnodinium aeruginosum* showed bimodal tolerance of temperature. In general, all the taxa grew better at 22±2°C.

(c) Maximum growth rate have been attained by different taxa at pH 8.

(d) Moderate growth occurred from 1500 lux to 3000 lux at 22±2°C, however, maximum occurred between 2000 lux and 2500 lux. It was found that a direct correlation occurs between light intensity and growth rate and the optimum light intensity required for majority of taxa is @ 2000 lux.

(e) Although good growth has been observed in ordinary white light but growth was also found equally well in red, yellow as well as blue light in most of the cases.

(f) It was found that shaking of cultures twice a day–once before the commencement of light period and the other after the light period, helped very greatly to maintain better growth of cultures.

(g) Neither continuous light for continuous darkness favoured growth of these organisms.

(iv) Effect of various chemical parameters on the growth

All the 8 algal taxa were subjected to test their growth in relation to various media viz. soil-water (biphasic), pond-water, Chu-10, von Stosch and Carefoot media and various nitrogen sources viz. 4 inorganic- $NaNO_3$, $Ca(NO_3)_2$, NH_4NO_3 and $NaNO_2$ and one organic—NH_2CONH_2. Levels of $NaNO_3$, $CaCl_2$, $MgSO_4$, NaCl, K_2HPO_4, KH_2PO_4, PIV-metals, Na_2EDTA, $NaHCO_3$, biotin, thiamin, vitamin B_{12} and combinations of vitamins preferentially required for the best growth of these taxa were determined. The following conclusions have been drawn.

(1) For the longer survival of the organisms, aged, sterilized pond-water medium (50 ml of pond water diluted with 40 ml of glass

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distilled water and 10 ml of soil-extract) was found better than soil-water (biphasic) medium.

(2) Of the various media tested, Carefoot, 1336 medium gave best growth for majority of the taxa in comparison to Chu-10 and von Stosch media.

(3) Amongst the five different nitrogen sources used, sodium nitrate was found to be the best source for nitrogen, however, three main groups, on the basis of preferential requirement of nitrogen source, were established Group A—sodium nitrate preferring algae—*Katodinium polyplasticum, Katedinium* sp, *Gymnodinium bohemicum, Gymnodinium paradoxum, Gymnodinium aeruginosum* and *Peridinium penardiforme*; Group B—calcium nitrate preferring alga - *Gymnodinium inversum* var. *inversum* and Group C—ammonium nitrate preferring alga - *Gymnodinium wawrikae.* However, *Gymnodinium bohemicum* preferred sodium nitrate as well as urea equally.

(4) The concentration of sodium nitrate needed for the maximum growth rate of all the taxa was determined which was 8.82 mM/l.

(5) Level of calcium chloride preferentially required was 0.52 mM/l.

(6) Almost all the taxa showed preference to 0.38 mM/l of magnesium sulphate.

(7) It was found that majority of taxa showed preference to 0.52mM/l of sodium chloride. The only one taxon *Gymnodinium inversum* var. *inversum* was euryhaline while the rest are stenohaline either sensitive to low or high levels of sodium chloride.

(8) The preferential levels of K_2HPO_4 and KH_2PO_4 required for the maximum growth of almost all the taxa was 0.10 mM/l of K_2HPO_4 and 0.34 mM/l of KH_2PO_4.

(9) In general, sodium bicarbonate was not preferred by any of the taxa except *Gymnodinium paradoxum* which required 0.402 g/l of sodium bicarbonate.

(10) It was found that better growth occurred in PIV-metal solution out of different trace-metal solutions tested.

According to the order of preference by various taxa, to various trace-metal solutions, they are categorized into two main groups. Group A—PIV-metal preferring algae—*Katodinium polyplasticum, Katodinium* sp., *Gymnodinium bohemicum, Gymnodinium inversum* var. *inversum, Gymnodinium paradoxum* and *Peridinium penardiforme* and Group B—PII-metal preferring alga

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Gymnodinium wawrikae. However, *Gymnodinium aeruginosum* preferred PIV-metal as well as PII-metal equally.

(11) The maximum growth rate in majority of the taxa, except *Gymnodinium aeruginosum* which showed better growth in 12.5 ml of PIV-metals, was preferentially attained in the medium when medium was supplemented with 10 ml of PIV-metal solution.

(12) Among the various concentrations of sodium—EDTA tested only 18.75 mg/l of Na_2EDTA gave better result for almost all the taxa, except one, *Gymnodinium aeruginosum*, which grew better at 22.5 mg/l of Na_2EDTA.

(13) Supplementation of higher concentrations of vitamins or vitamin mixtures caused more bacterial growth. Though it was found that a direct relation exists between growth rate and the concentration of vitamin B_{12} and thiamin, (in order to avoid the bacterial contamination) only 3 ug/l of vitamin B_{12} and thiamin were used. Although biotin was ineffective to enhance the growth, it was found that the mixture of three vitamins i. e. vitamin B_{12}+biotin+ thiamin at the concentration of 3 ug/l of each gave maximum growth.

Based on the above studies a new synthetic medium designated as 'modified Carefoot' medium was developed. This new medium in comparison to Carefoot basal medium originally formulated by Carefoot (Carefoot, 1968) proved very useful for the experimental algae in supporting for higher levels of growth and for their longer survival too.

A STUDY OF PHYTOTOXICITY OF OZONE AND SULPHUR DIOXIDE POLLUTANTS

Madhoolika Agrawal nee Madhoolika Singh Sup : *Dr. D. N. Rao*

The present study was undertaken to assess and compare the nature and magnitude of effects of O_3 and SO_2 pollutants, both singly as well as in mixtures, on selected plants of two species of cereals and two of legumes, known to be markedly different in their water requirement. Also, the pollutant exposed plants of *Vicia faba* were sprayed with 0.02 *M* aqueous potassium ascorbate solution to test the efficacy of this chemical as a growth ameliorating agent under conditions of O_3,

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SO_2 and O_3+SO_2 pollution. With these aims in view, four separate pollutant exposure experiments were conducted as mentioned below :

I. Plants of *Cicer arietinum* or gram, a low water requiring legume, were exposed to known concentrations of O_3, SO_2 and O_3+SO_2 pollutants on a long-term basis to determine the level of plant response to a given pollutant dose under conditions of low levels of soil moisture (10.0 – 11.5%) and relative humidity (60 – 70%).

II. Plants of *Oryza sativa* or rice, a high water requiring cereal, were exposed to O_3, SO_2 and O_3+SO_2 pollutants on a long-term basis and provided with a recuperation period of 10 days, as fumigation has to be suspended due to constant rains, to determine the level of plant response to pollutants under conditions of excessive soil moisture (32 – 35%) and high relative humidities (70 – 90%).

III. Plants of *Panicum miliaceum* or common millet, a moderate water requiring cereal, were exposed to O_3, SO_2 and O_3+SO_2 pollutants on a long-term basis to determine the level of plant response to pollutants under conditions of moderate soil moisture (18 – 20%) and relative humidity (35 – 50%).

IV. Plants of *Vicia faba* or broad bean, a moderate water requiring legume, were exposed to O_3, SO_2 and O_3+SO_2 pollutants and also sprayed with 0.02 *M* aqueous potassium ascorbate solution to test whether this chemical was able to mitigate or reduce the level of plant injury to pollutants.

Experiment I :

In the first experiment, gram plants were raised in 7 plots of m^2 each and when 60-day old, plants of each plot were enclosed with m^3 polythene chamber and exposed separately to O_3 concentrations of 0.04 ppm (T) and 0.08 ppm (T_1); SO_2 concentrations of 0.25 ppm (T_2) and 0.5 ppm (T_3) and O_3+SO_2 concentrations of 0.04+0.25 ppm (T_4) and 0.08+0.5 ppm (T_5) for 2 hrs daily from 60 to 100-day plant ages. Plants of one plot served as control (C). Plant samples from each plot were collected at 60, 70, 80, 90, 100 and 110-day plant ages.

The pollutant exposed plants showed yellowish interveinal foliar symptoms on the upper leaf surface after O_3 exposure and brownish interveinal symptoms on either leaf surfaces after SO_2 and O_3+SO_2 exposure. The amounts of chlorophyll and carotenoid were reduced in all sets exposed to O_3, SO_2 or O_3+SO_2 pollutants. Chlorophyll *b* was relatively more tolerant to pollutants in comparison to chlorophyll *a*.

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The leaf-extract pH values decreased only for SO_2 and O_3+SO_2 exposed plants.

A maximum reduction in the length of plant parts was noted for O_3+SO_2 (0.08+0.5 ppm) exposed T_5 plants. In all cases the treated plants showed a gradual decrease in phytomass with increasing pollutant concentration. Similar reductions were noted in the productivity of these sets. Seeds obtained from pollutant exposed plants showed decrease in weight, calorific value, mineral contents and accumulated metabolites.

Experiment II :

In the second experiment, rice plants grown in 4 plots of 1.5 m^2 each, were enclosed with 1.5 m^3 polythene chambers and exposed separately to 0.08 ppm O_3 (T), 0.5 ppm SO_2 (T_1) and 0.04 ppm O_3+ 0.25.ppm SO_2 (T_2) for 1.5 hrs daily between 40 and 60-day ages. Then, because of continuous rainfall, the fumigation was suspended and there was a 10-day recuperation period between 61 and 70-day plant ages. However, the plants were further exposed to pollutants between 71 – 80 day ages as per schedule given above.

Transpiration rate and relative leaf water content increased after exposure to O_3, SO_2 and O_3+SO_2 pollutants; the maximum increase being in T_2 or O_3+SO_2 exposed plants.

At any given age, the catalase activity of pollutant exposed plants was lower than those of the control plant. In contrast, the peroxidase activity increased in treated plants in comparison to control. The amounts of N, P, K and Ca decreased with respect to control in O_3, SO_2 and O_3+SO_2 exposed plants; but the S–content increased in SO_2 and in O_3+SO_2 exposed plants. Similarly, the metabolites like starch and protein were quantitatively reduced in pollutant exposed plants. The amounts of reducing and soluble sugars in O_3, SO_2 and O_3+SO_2 exposed plants were higher than those of the control.

The plants exposed to O_3, SO_2 and O_3+SO_2 showed reductions with respect to control, in their root and shoot lengths, numbers of leaves, tillers and ears, and phytomass accumulation as well as productivity levels; the maximum reduction being in O_3+SO_2 exposed and minimum in O_3 exposed plants. The pollutant induced changes in plants led to reduction in biological yield and deterioration in seed quality, especially with respect to weight, calorific and nutritive values.

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Experiment III

Plants of *Panicum miliaceum* in different plots. enclosed with m^3 polythene chambers, were exposed to 0.08 ppm O_3 (T) 0.5 ppm SO_2 (T_1) and 0.04 ppm $O_3 + 0.25$ ppm SO_2 (T_2) separately for 1.5 hrs daily for a 30-day period between 30 and 60 days of their life cycle. Collection of plant and soil samples for analyses were done at 30,40,50 and 60-day ages of plants.

It was noted that there were reductions in the various morphological parameters, phytomass accumulation and net primary productivity in pollutant exposed plants with respect to control. The quantity and quality of seeds obtained from treated plants were inferior to those obtained from the control ones.

Experiment IV

In this experiment, an attempt was made to test the phytotoxic ameliorating action of the aqueous solution of potassium ascorbate ($C_6H_7O_6K$) against O_3, SO_2 and $O_3 + SO_2$ pollutants For this purpose *Vicia faba* plants were raised in 8 plots of m^2 each. Plants in plot one served as control and those in plot 2 were sprayed at 45, 60, 75, 90 and 105 day ages with 250 ml of 0.02 *M* $C_6H_7O_6K$ solution. The plants in the remaining six plots were exposed daily for 1.5 hrs between 40 and 100 days of their life cycle with O_3 (0.08 ppm), SO_2 (05 ppm) and $O_3 + SO_2$ (0.04 + 0.25 ppm), using two plots for each set of pollutant exposure. The pollutant exposed plants of plots 3, 5 and 7 were left as such but those of plots 4, 6 and 8 were sprayed with 250 ml of 0.02 *M* potassium ascorbate solution at 45, 60, 75, 90 and 105-day ages. The plants of plots 1, 2, 3, 4, 5, 6, 7 and 8 were code named as C, CS, T, TS, T_1, T_1S, T_2 and T_2S, respectively. The plant and soil samples were collected at 40, 55, 70, 85, 100 and 115-day ages of plants.

Both pollutant exposed as well as pollutant exposed and $C_6H_7O_6K$ sprayed plants showed foliar symptoms characteristics of O_3, SO_2 and $O_3 + SO_2$ pollutants. However, the level of foliar injury in $C_6H_7O_6K$ sprayed plants was lower than that of the unsprayed ones. All sets of pollutant exposed plants had lower values of chlorophyll and carotenoid than those of control plants. The pigments chl *a* and *b* showed similar trend with respect to decrease in their quantity after exposure to pollutants. Likewise, with respect to control, the ascorbic acid leved decreased in treated plants The ascorbic acid contents irrespective of age in sprayed plants were invariably higher than those

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of the unsprayed ones. The leaf-extract pH values reduced in T_1, T_1S, T_2 and T_2S plants.

The different physiological and biochemical changes under conditions of O_3, SO_2 and O_3+SO_2 pollutants led to a decrease in the growth of plants, as quantified in terms of various morphological measurements, such as phytomass accumulation and productivity levels. Further, all plants sprayed with potassium ascorbate had better seed quality in comparison to the unsprayed ones.

Exposure experiments with O_3, SO_2 and O_3+SO_2 pollutants indicate that the plants vary in their susceptibility to pollutants and in the present case the sensitivity order for legumes is gram < broad bean and for cereals millet < rice.

On the basis of these experiments, it may be concluded that long term exposures of plants to low levels of O_3, SO_2 and O_3+SO_2 pollutants cause foliar lesion, chlorophyll reduction, metabolite decrease, seed quality deterioration, productivity losses, etc , that O_3+SO_2 act synergistically causing greater injury than when these pollutants act singly ; that the sensitivity of plants to pollutants may be a function of moisture regime around the plant body ; that the pollution free period of even a few days help plants to recuperate and achieve better growth and that the pollutant stressed plants are helped when sprayed with potassium ascorbate solution.

DRY MATTER PRODUCTION AND NUTRIENT CIRCULATION IN THE EVEN AGED PLANTATIONS OF *Tectona grandis* Linn. F.

Satish Kumar Srivastava Sup. : *Dr. S. S. Ramam*

This work deals with the work conducted on *Tectona grandis* ecosystem of central India (Madhya Pradesh). It is an important deciduous tree and produces the best quality of timber. Through extensive survey of working plan of Hoshangabad Division, Madhya Pradesh it became easy to locate and select various even-aged plantations of *Tectona grandis*. Six evenaged plantations of 3, 8, 12, 20, 29 and 37 years in age are intensively investigated on the following lines :

1. Stand structure and site features.
2. Dry matter production with special reference to its distribution in above-ground phenophases (bole, branch and leaf),

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3. Annual litter fall in terms of its status on the forest floor,
4. Energy flow, its storage, distribution and conservation efficiency in teak plantations,
5. Essential macro-nutrients status and its accumulation in biotic pool (Tree system),
6. Turnover and biological cycle in the light of uptake, retention and release patterns,
7. Essential macro-nutrients in terms of availability and storage in abiotic pool (Soil system),
8. Discussions on various features of *Tectona-ecosystem* in the light of available literature,
9. Applicable statistical tests.

Certain structural parameters viz. tree density, height, phenology, crown architecture, basal area and leaf area index are assessed for stand structure approach. Certain relations like girth vs density, basal area with density and height vs diameter^2 have been established for *Tectona grandis* stands.

The assessment of dry matter production in this version is based on the selective harvest method where sample trees represent various girth class and the method was applied for each of the forest stand. The profile architecture of biomass for each sample tree as well as for each forest stand is drawn to depict the canopy structure of *Tectona ecosystem*. The canopy thus pooled, constructs the conical or inverted bowl shape except in some younger plantations where its seems to be cylindrical.

Maximum standing biomass is recorded 88.22 t/ha for 29 year old forest stand and its relative distribution in bole, branch and leaf falls 85%, 12%, and 3% of the total above ground biomass respectively. The results show an increasing pattern upto 29 year old plantation and a decline in biomass concentration is expressed by the 37 yr old forest stand thereafter due to the corresponding lower values of the density (520 trees per hectare).

The litter fall of current year (1977) lies minimum (1.81 t/ha) in younger plantation (3 yr) with a consistent increase with the maturity of the forest stand. The maximum amount of litter production is 10.76 t/ha (37 yr). The relative percent distribution is 63%, 13%, 5% and 19% for leafy litter, perennial woody parts, fruits and infloroscence and duff deposited just above the soil horizon on the forest floor respectively.

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The mean annual increment in biomass ranges from .99 t/ha (12 yr) to 3.04 t/ha (29 yr). The values of current annual increment account for minimum from 8 yr old plantation (.75 t/ha) and maximum is recorded for 6.05 t/ha from 29 yr old forest stand. Net primary production shows consistent increasing pattern with a maximum record of 12.61 t/ha from 37 yr old forest stand.

Certain allometric equations and correlation coefficient for diameter vs above ground biomass (bole, branch and leaf) and diameter^2 $\times$ height vs above ground biomass are developed for equating each sample trees. In addition to these certain biomass ratios and production interrelations like biomass accumulation ratio, wood production vs litter production and litter mass vs basal area, are established in various teak plantations.

The calorific concentration for bole (3946-4897 g. cal/gm), branch (4070-4842 g. cal/gm) and leaf (4658-5037 g. cal/gm) on dry weight basis and on ash free dry weight basis for bole (4134-5156 g. cal/gm), branch (4389-5101 g. cal/gm) and leaf (5968-5108 g. cal/gm) is estimated for the calculation of energy storage in teak plantations. The energy storage in teak plantations lies between 20.84×10^9 g. cal/ha-412.89×10^9 g. cal/ha. The maximum storage of energy is recorded from 29 yr old forest stand, where bole, branch and leaf record for 79%, 18%, and 3% respectively of the above ground energy storage.

The calorific concentration in the litter mass ranges between 3176-4645 g. cal/gm for leafy litter and 972-3181 g. cal/gm for duff content. The values obtained for litter are lower than that of leaves. The energy storage in litter mass attains the maximum range of 36.30×10^9 g. cal/ha. Energy conserving efficiency in litter mass could attain only .0086.0441% under 3-37 yr old teak forest stand.

The production efficiency of *Tectona grandis* ecosystem varies from .0170-.0533% of the photosynthetically available solar radiation. The values are more or less uniform for lower values in younger stands (3, 8 and 12 yr) and for higher values in older stands (29 and 37 yr).

The concentration of ash and various macronutrients viz. nitrogen, phosphorus, calcium, magnesium and potassium is estimated for each of the sample trees. The highest concentration among macro-mutrients is achieved by calcium and its corresponding values for bole, branch and leaf lies between 1.32-2.75%, 1.03-2.90% and 2.12 3.90% respectively.

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The maximum storage of elements is recorded from 29 yr old forest stand like 6658.5 kg/ha for ash, 913.41 kg/ha for nitrogen, 129.89 kg/ha for phosphorus, 2009.67 kg/ha for calcium and 484.62 kg/ha for potassium exceptimagnesium for which maximum storage 227.40 kg/ha) is recorded by 37 yr old forest stand.

The maximum values of annual uptake in *Tectona ecosystem* of the various elements are 202.76 kg/ha/yr for nitrogen, 20.15 kg/ha/yr for phosphorus, 243.33 kg/ha/yr for calcium, 42.31 kg/ha for potassium (from 29 yr old forest stand) and 39.89 kg/ha for magnesium (from 37 yr old forest stand). In all the forest stands the values of release (annual return through litter fall) is higher than that of retention in each of the forest stand for all the macro-nutrients. The annual return could pass its maximum concentration via litter fall viz. 171.26 kg/ha of nitrogen, 15.67 kg/ha of phosphorus, 174.03 kg/ha of calcium. 18.05 kg/ha of magnesium and 25.60 kg/ha of potassium (from 29 yr) on the forest floor. The magnitude of uptake of the various elements is headed by the calcium followed by nitrogen, potassium magnesium and phosphorus.

Teak plantation soils are also studied for its relative physico-chemical properties for various soil samples of different horizons. The concentration of organic carbon, total nitrogen, available phosphorus, exchangeable forms of calcium, magnesium and potassium are determined for each 30 cm horizons upto 90 cm soil depth in six plantation soils under 3-37 yr in age. In some plantations upper horizon of 0-30 cm, soils are found to be rich in nutrients but in other stands certain exchangeable cations were found to be higher than that of the top stratum. It is due to leaching activity of certain cations which were passed to the deeper horizons. The C/N ratio of the various soil samples lies between 5.46-17.18 and most of the ratios fall between 8-14.

The nutrient reserves in abiotic pool (soil system) are computed on per hectare basis area down to 90 cm depth. The values of maximum storage in soils are 142.57 t/ha for organic carbon, 17.80 t/ha for nitrogen, 691 kg/ha for available phosphorus, 57.57 t/ha for calcium (12 yr), 2.64 t/ha for magnesium and 1.94 t/ha for potassium (29 yr).

An attempt of the genesis of the Bori-plantation soil has been dealt for *Tectona* ecosystem so as to place the soils under 'Brown Earths' in the course of lateritic soil development.

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STUDY OF WHEAT-CROP ECOSYSTEM INFLUENCED BY CARPET INDUSTRY WASTES

Kailash Nath Mishra Sup : *Dr. R. S. Ambasht*

On small scale, cottage industries of woolen carpet manufacture have developed very rapidly during last decade in Varanasi district. The present investigation has been conducted to evaluate the effects of wastes from carpet industries on the wheat crop ecosystem. Fields selected for the detailed investigations are located around one of the biggest concern E. Hill & Company (situated about 50 killometers west from Banaras Hindu University) in the villages Mukundpatti and Damodarpatti near Khamriya town of Varanasi district.

Huge amount of chemicals such as $(NH_4)_2\ SO_4$, Na_2SO_4, heavy metal chromium $K_2Cr_2O_7$, CH_3COOH and dyes at low pH 4.3 and high temperature (60°C) are let out from the dyeing of wool yarns. Caustic soda (NaOH), bleaching powder ($CaOCl_2$) and soap with effluent water come out at large scale from the processing of woolen carpet. Washing soda (Na_2Co_3), soaps and other residues of dyeing process are discharged from scouring and washing of raw wool yarns.

(i) The processing wastes (S_1) is let out at 40°C, with high salt content (electrical conductance about 14.5 m mhos/cm) and greater amount of chemicals at pH 10.9, (ii) the dyeing effluent (S_2) is discharged and reaches in field at 60°C, contains large amount of chemicals with greater salt content (Ec 17.2 m mhos/cm) at pH 4.3, (iii) washing effluent (S_3) is given out at 35°C contains plenty of chemicals (Ec 6.63 m mhos/cm) at pH 8.6.

The effluents and well water have been analysed periodically about 20 days interval at the time of irrigations for temperature, colour, odour, pH, dissolved suspended and total solids, salt activity (electrical conductance), nitrate, ammonium and total nitrogen, sodium, potassium, calcium magnesium, chromium (VI), chloride, sulphate, phosphate, carbonate and dye content.

Simultaneously the soil samples were also collected from two depths : (i) upper 0-15 cm layer and (ii) lower 15-30 cm depths, and analysed for colour, texture, bulk density, percent porosity, moisture percentage, water holding capacity (WHC), pH, electrical conductance, percent organic matter content, exchangeable cations sodium, potassium, calcium and magnesium, cation exchange capacity, hexavalent chromium, nitrate, ammonium and total nitrogen, phosphorus, chloride, sulphate and carbonate.

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The vegetation of wheat crop ecosystem has been analysed for phytosociological attributes, frequency, density, abundance, relative frequency, relative density, relative dominance, importance value index and percent similarity index values in three consecutive months.

The seed germination studies were conducted in laboratory as well as in field conditions for the influence of (i) 25, 50, 75 and 100% concentrations of effluents; (ii) various concentrations of pure chemicals (0.06, 0.12, 0.18 and 0.24% of NaOH, $CaOCl_2$ and $K_2Cr_2O_7$) separately in Petri dishes. The seed germination and inhibition percentage as compared to control was also computed.

Under the effluent irrigation stress field conditions the vegetation was analysed for its (A) vegetative growth performance as (i) shoot length, (ii) tillering with pseudotillers (tillers without spike), (iii) number and size of leaf, (iv) culm diameter, (v) nature and extent of acute symptoms, (vi) root extension (vertical and lateral spread with their volume) at 20 to 100 day age, (vii) reproductive characters as size of spike, number of grains per spike, weight of 1,000 grains, grain yield per m^2 were also analysed.

(B) Variation in standing crop phytomass, rate of primary productivity of entire plant and in components (leaf, culm, spike and root) with their calorific values were studied at 20 days interval. (C) The wheat crop ecosystem was also analysed for (i) surface green area (Pho AI) and (ii) chlorophyll content in leaf and culm. The mineral elements (nitrogen, phosphorus, potassium, sodium, calcium, chromium, chloride and sulphate) levels in leaf was also studied at 20 days interval.

Pot culture experiments in garden were also conducted for (A) organic manuring effect of 7g (B_1), 14 g (B_2), 21 g (B_3) and 28g (B_4) of buzbun (wool particle wastes) in per pot soil. (B) Irrigation effects of 0.08% solutions of (i) pure chemicals (NaOH, $CaOCl_2$ and $K_2Cr_2O_7$) separately and (ii) in combinations as composite salt mixtures :

(a) I (0.5 g NaOH + 0.25 $CaOCl_2$ + 0.25 g soap), and in one g mixture, and

(b) II (0.2 g $(NH_4)_2SO_4$ + 0.27 g Na_2SO_4 + 0.18 g $K_2Cr_2O_7$ + 0.23 g acetic acid + 0.12 g dye in 1 g mixture) separately.

Wheat *Triticum aestivum* L variety RR-21) plants were analysed for (i) shoot length, (ii) tillering (with pseudotillers), (iii) number and size of leaf, (iv) culm diameter, (v) root extension, (vi) reproductive characters size of spike, grains per spike, weight of 1,000 grains and grain yield per plant, (vii) plants were also analysed for dry matter

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production in components (leaf, culm, spike and root) and total with the rate of primary productivity.

Vegetation Studies in Field Conditions

Phytosociology

The maximum of 13 in C field and minimum of 6 species in S_1 field, with 7 and 11 species in S_2 and S_3 fields respectively were constituted the vegetation of wheat crop ecosystem in varying field conditions, showing a great variation. *Asphodelus tenuifolius, Chenopodium album, Cynodon dactylon* and *Cyperus rotundus* with wheat (*Triticum aestivum* L Variety RR-21) plants were common in all the fields, *Melilotus alba* in S_3 field, *Portulaca oleracea* and *Phaloris minor* were exclusively confined to C field.

The four species *Anagallis arvensis, Lathyrus aphaca, Polygonum plebejum* and *Vernonia cinerea* were exclusively recorded from S_3 and C fields only.

Asphodelus tenuifolius has attained the highest IVI values and *Chenopodium album* has occupied 2nd position, respectively in C, S_3, S_2 and S_1 fields. The percent similarity index was maximum (72.7) in S_3, followed by 66.6 in S_2 and minimum of 58.8 in S_1 fields, showing a large difference as compared to vegetational associations of C field.

Variation in Physicochemical Properties of Soil

The porosity of soil has decreased by 12.73% in S_1, 8.9% in S_2, 5.19% in S_3 fields resulting into a reduction in water holding capacity by 6.95% in S_1, 4.7% in S_2, 2.24% in S_3 fields as compared to C field. The soil pH has increased from 8.5 to 9.8 in S_1, 7.9 to 8.9 in S_3 fields and decreased from 6.0 to 5.0 in S_2 field from seed sowing to dough (120 days) stage of wheat crop.

The electrical conductance (in m mhos/cm) of soils has increased from 4.5 to 13.3 in S_1, 5.6 to 17.5 in S_2, 4.1 to 12.15 in S_3 fields from seed sowing to dough (120 days) age of wheat crop.

The S_1 soil, irrigated with processing effluent has shown an increase in sodium (from 6.4 to 14.8 me/100g), in calcium (5.7 to 7.7 me/100 g), chloride (225 to 340 mg/100g), content with a decrease in potassium (from 4.2 to 1.65 me/100g), magnesium (from 3.56 to 1.36 me/100g), sulphate (from 37 to 23 mg/100g), total nitrogen (from 182 to 140 mg/100g) with 40.38% reduction in phosphorus content,

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resulting into a great increase from 29.63 to 65.2% in exchangeable sodium percentage, at seed sowing to 120 day age of wheat plants.

F were highly significant at 0.1% probability level.

Variation in Seed Germination of Wheat

The percentage inhibition in wheat seed germination has progressively increased from 23 to 47 and 2 to 25, with increasing concentration from 25 to 100% respectively in processing and washing effluent treatments as compared to that of water treated control condition at 120 hr incubation.

The percentage inhibition in seed germination has gradually increased from 19 to 45 in 0.11% solutions of caustic soda (NaOH), 21 to 49 in 0.06 to 0.18% solution of $CaOCl_2$ and 13 to 52 in 0.06 to 0.24% solutions of $K_2Cr_2O_7$ at 120 hr incubation.

The percentage inhibition in seed germination has progressively increased from 11 to 37 in 0.1 to 0.3% soil salinization by composite salt mixture I, whereas it was 8 to 34 in 0.1 to 0.3% soil salinization by composite salt mixture II at 168 hr incubation.

In field conditions the seed germination was affected in the beginning, being 55% in S_1 and 60% in S_3 at 96 hr incubation. It has attained 90% in S_1 and 97% in S_3 fields at 168 hr incubation.

In Petri dishes seeds were germinated at 48 to 120 hr incubation. In soil salinization and field conditions at about field capacity moisture level the seed germination started at 96 hr and completed at 168 hr incubation. The seed germination in effluent and solution sprinkled Petri dishes started at 48 hr and completed at 120 hr incubation.

In Petri dish conditions various grades of effluents have badly inhibitted the seed germination but in field conditions the inhibitary effect on germination was mild.

Variation in Growth Performance. Dry Matter Production and Energy Content

Shoot growth was reduced by 16.26 to 27.64% in S_1, 8.94 to 24% in S_2 and 4.06 to 17.45% in S_3 fields as compared to C field at 20 to 100 day age. The percentage reduction of 25, 20, 15 in tillering (with 24.9, 21.94 and 17.9% pseudotillers); 29, 25, 22 in number of leaf; 31.4, 29, 26 in leaf size; 22.8, 15 2, 13.6 in culm diameter; 13.05, 9.12, 6 55 in vertical spread; 9.6, 7.64, 5.73 in lateral spread; 9.8, 7.7, 5.5 in root volume was marked as compared to C field respectively in S_1, S_2 and S_3 fields.

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The percentage reduction of 27.5, 24.4, 17.5 in size of spike; 19.4, 17.4, 14.2 in number of spikelets; 15, 13, 10 in number of grains per spike resulting into 66.37, 55.4, 44.7 in grain yield was obtained as compared to C field, respectively in S_1, S_2 and S_3 fields.

In young vegetative stage some acute symptoms of mottling, chlorotic patches and in older stages the necrosis of tips, margins and interveinal areas of leaf with very much reduced growth of plants was marked in S_1 field.

Purple greenish or brownish red leaves with necrotic areas and burnt up appearance in interveinal yellowing of leaf was also marked in acute symptom stages in S_2 field.

The percentage reduction of 44.98, 40.13, 32 04 in leaf phytomass (g/m^2) at 80 days; 46.82, 41.57, 33.42 in culm phytomass at 100 days; 21.06, 19 61, 17.67 in root phytomass at 100 days. 50.88, 45.4, 37.7 inspike phytomass; 15, 13, 10 in number of grains; 25, 20, 18 in weight of 1000 grains was obtained resulting into a percentage reduction of 66.34, 55.4 and 44.7 in grain yield respectively in S_1, S_2, S_3 fields as compared to C field.

The percentage reduction of 48.88, 43.2, 35.1 in above ground phytomass; 22, 20, 18 in under ground phytomass with 44.02, 39.32 in total dry matter production was marked respectively in S_1, S_2 and S_3 fields as compared to C field.

A marked reduction of 14, 9.57 and 4.67% in leaf calorification, 10.25, 7 74 and 4.6% in culm energy; 10.4, 7.95 and 4.09% in root energy was marked at their peak growth respectively in S_1, S_2 and S_3 fields as compared to C field. This has resulted in a significant reduction of 11.01, 8.2 and 4.32% in spike energy respectively in S_1, S_2 and S_3 fields.

Variation in Photosynthetic Structure and Mineral Contents

A percentage reduction of 37, 34 and 31 in surface green area; 36.24, 29.95, and 22.13 in chlorophyll a; 29.3, 23, and 16.9 in total chlorophyll of leaf with 35.2, 29.5 and 22.26 in chlorophyll a; 22.04, 19.05, 14.56 in total chlorophyll of culm was obtained respectively in S_1, S_2 and S_3 fields as compared to C field.

There has been a reduction level of nitrogen (37.74% in S_1, 23 02% in S_2, 26.98% in S_3); phosphorus (38.85% in S_1, 18.2% in S_2); potassium (40.5% in S_1, 24.27% in S_3) and calcium (40% in S_2, 25.9% in S_3) as compared to C plants.

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Sodium in leaf has accumulated from 1.5 to 4.2% in S_1; 0.87 to 2.4% in S_2 and 1.3 to 3.6% of dry weight of plant part in S_3 plants at seedling (20 days) to its peak growth of boot (80 days) stage. The sulphur in leaf has accumulated to 0.353% in S_2 and 0.084% in S_3 plants. The chloride in leaf has accumulated to 2.88% in S_1, 1.43% in S_3; whereas the concentration of chromium was 0.112% in S_2, 0.054% in S_3 at 80 day age.

(A) Pot Culture Experiments : Organic Manuring by Buzbun

The percent increase of 17.5, 22.4, 26.8 and 30.4 in shoot length; 3.9, 5.2, 6.4, 7.7 in tillering; 8.5, 11.03, 13.5, 16.2 in number of leaf; 10, 11.9, 14, 17.9 in size of leaf; 8, 11, 13, 16 in culm diameter, 4.1, 4.6, 5.2, 5.7 in vertical spread of root; 4.9, 6.1, 6.6, 7.3 in root volume; 3.97, 5.95, 7.9, 9.5 in size of spike, 19.5, 21.5, 23.5, 25.52 in total phytomass, 5.2, 6.2, 7.2 and 8.3 in root phytomass was recorded respectively in B_1, B_2, B_3 and B_4 pots in comparison to that of B_0 (without buzbun) pots.

An enhancement in rate of production was by 14.23, 15.89, 18.3 and 20.52% respectively in B_1, B_2, B_3 and B_4 pots as compared to that of B_0 pots at its peak growth of boot (80 days) age. This has resulted into an increase of 20, 25, 30 and 35% in B_1, B_2, B_3 and B_4 as compared to B_0 pots.

In bivariant analysis for growth performance, standing crop phytomass, dry matter production and grain yield, the obtained values of F were highly significant at 0.1% probability level.

In bivariant analysis for growth performance, dry matter production in components and the entire plant, the obtained values of F for various doses of buzbun and growth stages were highly significant at 0.1% probability level.

(B) Pot Soil Treated with Solutions of Various Chemicals

The percentage reduction of 9.7, 12.6, 15.4, 17.9, 20.63 in shoot length; 12.5, 14.7, 19 3 22.72, 31.81 in tillering (with 17, 18, 20, 22 and 25% pseudotiller i. e. tillers without spike); 12.2, 19.94, 20.3, 25.6, 27.02 in leaf number, 18.13, 21.78, 25.38, 28.82, 31.2 in leaf size, 11.4, 14.3, 17.14, 20, 22.85 in culm diametre, 6.6, 8.4, 10.7, 13.0, 14.6 in root extension; 6.5, 8.25, 10.76, 13.0, 14.57 in root volume; was marked at their peak growth respectively in mixture II (M_2), mixture I (M_1), $K_2Cr_2O_7$ (P_3), $CaOCl_2$ (P_2) and NaOH (P_1) treated pots in comparison to C pots.

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A marked variation with reduction percentage of 8.6, 10, 13.8, 18.4 and 23.0 in growth of spike, 7.9, 10.5, 13.2, 15.8 and 18.4% in number of grains; 5.6, 7.4, 9.0, 11.6 and 14% in weight of 1000 grains resulted into 31, 34, 37, 41 and 46.7 in grain yield per plant respectively in M_2, M_1, P_3, P_2 and P_1 pots as compared to C pots.

The effluents discharged from (i) processing of wollen carpets, (ii) dyeing and (iii) washing of wool yarns in carpet industry have greatly altered the physiochemical properties of the soils. The effluent irrigation treatments have adversely altered the pH, salt activity, thereby disturb the optimal ionic balance of soil and reduce the availability of essential elements (i. e. N, P, K and Ca) and increased the accumulation of chromium, Na, Cl and sulphate.

Organic manuring (was done two months before the seed sowing) of soil by various doses of wool particle waste (buzbun) has increased the growth processes of wheat plants resulting into increased dry matter accumulation and grain yield in pot culture conditions.

STUDIES ON EUKARYOTIC ALGAE WITH PARTICULAR REFERENCE TO THEIR KARYOLOGY

Tapas Kumar Chowdhury Sup. ; *Dr. Y. S. R. K. Sarma*

Observations have been made on desmid taxa in relation to (a) morphology and karyology (b) conjugation process and (c) radioprotection against UV-light.

(a) Morphological studies of 49 taxa of placoderm desmids belonging to the genera *Cosmarium, Closterium, Euastrum, Micrasterias, Staurastrum, Xanthidium, Desmidium,* and *Onychonema* were undertaken, of which 41 taxa were karyologically investigated and their chromosome numbers were determined The karyological data were considered for cytotaxonomic assessment.

The mitotic cycle in three desmid taxa *Cosmarium qoadrum, Euastrum inermios* and *Staurastrom forficulatum* was studied in relation to varying light and dark regimes.

Chromosome numbers obtained in the present study have been listed in table 1. In the genus *Cosmarium* chromosome numbers exhibited a wide range from n = 7 in *C. quadrum* and *Cosmarium* sp. 39 to n = 46 in *C. moniliferme* var. *gigantica*. The chromosome number

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n = 7 recorded in the present study is the lowest chromosome number recorded so far (cf. Sarma, 1982) in the genus *Cosmarium*.

The chromosomes of the desmids during present investigation were either rod-or dot-shaped. The centromeric position could not be observed in most cases because of their minute size. In the case of small rods they appear to be polycentric as in *Cosmarium* sp. 42.

The chromosome numbers n = 42 ± 2 and n = 64 ± 2 have been encountered for *Closterium turgidum* and *Cl. acerosum*, respectively, of which former is first report and latter is new addition to the pre-existing records.

Regarding the genus *Euasirum*, four species have been karyologically investigated. While *E. inermius*, *E. binale*, *E. crenatum* gave chromosome counts as n = 12, n = 13 and n = 12, respectively, *E. sculptum* reflected four chromosomal races viz., n = 21, n = 16, n = 15 and n = 9. In this genus all the chromosome numbers are new records.

For the genus *Micrasterias*, chromosome number n = 36 for *M. crux-melitensis* is a new addition to the existing records and n = 38 for *M. incisa* is first record.

The genus *Staurastrum* offered wide range of chromosome numbers from n = 6 in *S. pilosum* to n = 44 in *S. echinatum* among nine species studied karyologically. It is noteworthy that the chromosome number n = 6 for *S. pilosum* is the lowest chromosome number ever reported in any of the desmid taxa as listed by Sarma (1982).

For the first time the genus *Xanthidium* has been worked out karyologically and the chromosome numbers n = 31 ± 1 and n = 35 for *X. bengalicum* and *Xanthidium* sp., respectively have been determined.

The genus *Desmidium* was also studied karyologically to record chromosome number n = 15 in *D. baileyi* and n = 14 for *D. occidentale* for the first time. Chromosome number n = 17 in *D. swartzii* is a new addition to the earlier records.

For the first time, in the genus *Onychonema*, chromosome number n = 11 was observed in *O. compactum*.

Two chromosomal races, n = 13 and n = 26 ± 1 in *C. undulatum*, and n = 7 and n = 19 in *C. quadrum* were observed. Further, four chromosomal races were also encountered in *Euastrum sculptum* as n = 21, n = 16, n = 15 and n = 9. These chromosomal races appear to have arisen in an aneuploid manner. Based on earlier work and the present study, it is clear that desmid chromosomes also are of polycentric nature having nonlocalized centromeric position and hence,

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frequent fragmentation and unequal separation of chromosomes seem to have played an important role in establishing such chromosomal races through "Agmatoploidy".

On application of different light and dark cycles viz., 16h/8h, 12h/12h, 8h/16h, 20h/4h, 4h/20h and continuous light or dark on three desmid taxa : *Cosmarium quadrum*, *Euastrum inermius* and *Staurastrum forficulatum*, it was found that minimum eight hours of light or dark but not more than 16 hours is essential, for completion of nuclear division in the three taxa studied. However, 16h/8h and 12h/12h LD cycles were more conducive. The mitotic peaks were entirely confined to the dark phase. The variables of light and dark regimes have been employed for the first time to study the response of mitotic cycle in desmid taxa.

(b) Two species of *Closterium* viz., *Cl. acerosum* and *Cl. turgidum* were selected, in which conjugation was induced on application of a new synthetic nitrogen depleted medium especially devised in present study. Several other techniques were also applied with no positive results of achieving conjugation. Further, sexual activity and burst frequency were also calculated by appropriate formulae. Conjugation process was also observed in the three species of *Cosmarium*. Besides, zygospore characters of eight species of *Cosmarium* are also discribed. Some attempts to break the dormancy of zygospores and induce their germination were made in *Closterium acerosum*.

Not less than 100 clones were raised from samples collected from different localities for both the taxa. Homothallism could not be observed in any case in either taxa. However, heterothallism was established in 20 combinations of *Cl. acerosum* and 11 combinations of *Cl. turgidum*. Following common processes have observed in both the taxa are : (i) two conjugants participate in conjugation, (ii) pairing of the two conjugants is essential, (iii) conjugation takes place by means of papillae, (iv) both the papillae of respective conjugants form a common conjugating tube, (v) fusion of the gametic protoplast takes place within the conjugation tube, and (vi) zygospores develop within the conjugation tube. In spite of these common features of conjugation, both the taxa differed in the process. In *Cl. acerosum* mother cells divide to form gametes which later on pair with the gametes of opposite strains. The members of a pair differed in size, thus fusion is heterogamous. On the other hand, in *Cl. turgidum* mother cells of opposite strains undergo pairing first and then divide synchronously to form four gametes, all of which take part in conjugation, and consequently resulting into formation of twin zygospores Some gametes.

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though develop papillae without entering into conjugation in both the taxa, the sexual activity and burst frequency have also been calculated. It was noted that the ratio of two opposite strains being more favourable to sexual activity was not the same as in burst frequency. Burst frequency increased in conditions which prevent pairing. Further, it was noted that cells were sexually activated at the beginning of second and third light phase in *Cl. acerosum* and *Cl. turgidum*, respectively, which focuses that light and dark regime plays significant role in conjugation.

Among the two species of *Cosmarium* the conjugation process, which was observed from normally growing laboratory cultures, was very much similar to each other and further to *Cl. acerosum*. However, the study of the zygospores in the nine different species of the genus *Cosmarium* showed remarkable dissimilarity in size and structure and seems to be a valid basis of their speciation.

(c) Three radioprotective chemicals, thiourea, caffeine and cysteine were selected to study the modifying effects of UV light on four taxa, viz., *Cosmarium lundellii, C. quadrum, Euastrum inermius* and *Staurastrum forficulatum*. Two concentrations (10^{-1}M and 10^{-2}M) of each chemical have been used in pre- and post-treatments.

In all the four taxa studied each chemical in either concentration has increased the level of percentage survival in comparison to control. However, the extent of survival differred not only from genus to genus but also species to species. The extent of protection is positively correlated with the concentration of the radioprotective chemicals. On the whole each chemical imparted antagonistic effect to UV-light in pretreatments. *Euastrum inermius* gave more survival values when pretreated with thiourea and cysteine and *Cosmarium quadrum* gave more survival values when pretreated with caffeine. But in pretreatment with each chemical *Staurastrum forficulatum* rendered least survival values.

In post-treatment thiourea and caffeine lowered the survival values in each of the taxa, thus imparted synergistic effect, which, however was strongly expressive in higher concentrations viz., 10^{-1}M. On the other hand cysteine was exceptional in offering antagonistic effect to UV-light, when used as post-treatment chemical in each of the taxa.

A comparison of modifying effects of all the three chemicals used unequivocally rendered antagonistic effect in pretreatments in all the four desmid taxa, and in post-treatments offered synergistic effect barring cysteine. Of the three, caffeine bestowed more protection in

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pretreatments and was more synergistic in post-treatment. Cysteine was exceptional in offering antagonistic effect either in pretreatment or post-treatment.

TABLE No. 1

Chromosome Numbers of Desmids in Present Investigation

Name of Species		Chromosome Number
1. *Csomarium undulatum* Corda	Strain A	13
	Strain B	26 ± 1
2. *Cosmarium Lundellii* Delp		16
3. *Cosmarium psedonitidutum* var *Validum*		30 ± 2
4. *Cosmarium quadrifarium* Lund f. *Polysticha*		n:22
5. *Cosmarium subcostatum* Nordst.		n:16
6. *Cosmarium sphaeroidium* West.		n:27
7. *Cosmarium conspersum* var *rotundatum* f *intermedia*		n:18
8. *Cosmarium moniliforme* f. *gigantica*		n:46
9. *Cosmarium* spp 42		n:19
10. *Cosmarium pyramidatum* Breb		n:14
11. *Cosmarium tumidum* Lund		n:30
12. *Cosmarium moniliforme* forma *punctata* Lagarh;		n:34
13. *Cosmarium tenue* Arch		n:25
14. *Cosmarium auriculatum* Reinsh		n:27
15. *Cosmarium quadrum* Lund	Strain A	n 19
	Strain B	n: 7
16. *Cosmarium taxicondriforme*		n:18
17. *Cosmarium reniforme*		n:15
18. *Cosmarium* spp 32		n: 7
19. *Cosmarium* spp 9		n:17
20. *Closterium turgidum*		n:42 ± 1
21. *Closterium acerosum*		n:64 ± 2
22. *Euastrum inernius* var *Burmese*		n:12
23. *Euastrum binale*		n:13
24. *Euastrum crenatum*		n: 9
25. *Euastrum sculptum*	Strain A	n:21
	Strain B	n:16
	Strain C	n:15
	Strain D	n: 9

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26.	*Micrasterias crux-melitensis*	n:36
27.	*Micrasterias incisa*	n:38
28.	*Staurastrum forficulatum* Lund	n:18
29.	*Staurastrum punjens* Breb	n:12
30.	*Staurastrum contectum* var. *Invevolulum*	n:10
31.	*Staurastrum Dickie* var *circulare* Turn.	n:20
32.	*Staurastrum nonanum* f. *minor*	n:18
33.	*Staurastrum pilosum*	n: 6
34.	*Staurastrum sonthalianum*	n:24
	Staurastrum echinatum	n:44
35.	*Staurastrvm cerastes*	n: 7
36.	*Xanthidium Bengalicum*	n:31±1
37.	*Xanthidium* spp	n:65
38.	*Desmidium Bailyi*	n:15
39.	*Desmidium schwartzil*	n:17
40.	*Desmidium occidentale*	n:14
41.	*Onychonema compactum*	n:11

BIOLOGY AND PROPAGATION OF *Gelidiella acerosa* (FORSSKAL) FELDMANN et HAMEL IN THE MANDAPAM REGION

P. V. Subba Rao Sup. : *Dr. Y. B. K. Chowdary*
Dr. K. Subbaramaiah (External)

Gelidiella acerosa (Forsskal) Feldmann et Hamel (Phodophyta) yields high grade agar, and is continually subjected to indiscriminate harvesting for supplying raw material to the agar industry. In the present study, the following aspects of .the biology of *G. acerosa* have been investigated.

I. Growth of the alga in nature : (A) Population studies including the deep water ones, (B) Individual growth characteristics, (C) Effect of transplantation on the growth of the alga, (D) Effect of harvest on productivity, and (E) Methods of enhancing algal growth in nature.

II. Factors controlling the characteristics of agar produced by the alga : Effects of (A) pH on extraction, (B) seasonal variation, (C) depth, (D) geographical location, (E) reverse transplantations,

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and (F) pretreatment with growth regulators. Following the investigations, certain suggestions/recommendations have been made for better management of the natural resources of this agarophyte.

G. acerosa is abundant in Indian waters and in distribution it spans the equator and occurs most frequently in Indo-Pacific region. In India it has been reported from South-East coast of Tamil Nadu and adjoining islands, as well as in the west coast at Veraval, Porbandar, Dwaraka and Okha, and in Lakshadweep Islands. *G. acerosa* was known to inhabit the tide pools in the intertidal region particularly along the margins at Veraval, and in the surf exposed areas in the intertidal region in Tamil Nadu.

In the present study, the natural growth of *G. acerosa* in the Mandapam region has been investigated from two contrasting ecological habitats : (1) Lagoon habitat at Rameswaram in the Palk Bay, and (2) the open shore habitat at Ervadi in the Gulf of Mannar, mainland shore. Natural growth of *G. acerosa* population and individual plants was studied at monthly intervals for a period of two consecutive years, July 1977 to June 1979. The population study consisted of population density percentage cover and its associated seaweeds. And in the individual plant studies, the height, number of branches, bushiness, fresh and dry weight of 25 plants, extension growth rate, and monthly growth rate, the occurrence of decapitated branches and secondary rhizoidal branches, and the frequency of tetrasporic plants were determined. Percentage water content in the plant biomass was also calculated.

The natural growth studies brought out the following results of the population.

1. The maximum density (wet) was found to be 35 ± 7 g/0.5m^2 at Rameswaram and 192 ± 45 g/0.5m^2 at Ervadi with the maximum values for dry weight 8 ± 2 g/0.5m^2 at Rameswaram and 54 ± 12 g/0.5m^2 at Ervadi.
2. The maximum density (number of plants) recorded was 38 ± 9 and 48 ± 12 respectively at Rameswaram and Ervadi.
3. The percentage cover was 26.7 ± 7.6 at Rameswaram and 75.2 ± 17.7 at Ervadi.
4. The density (dry wt.) and percentage cover on average were more by 6.2 and 2.8 times at Ervadi.
5. The ratio of fresh weight to dry weight was found to be 3.9:1.0 and 3.65:1.0 at Rameswaram and Ervadi respectively.

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The study of individual plants gave the following results.

1. The maximum height recorded as 6.0 ± 0.3 cm and 6 5 ± 1.65 cm at Rameswaram and Ervadi respectively,
2. The maximum number of branches were 17 ± 1 at Rameswaram and 148 ± 42 at Ervadi,
3. The maximum bushiness noticed was 49.7 ± 3.6 cm and 402 25 ± 115.4 cm at Rameswaram and Ervadi respectively,
4. Three types (A, B, & C) of plants were found at Ervadi,
5. The maximum dry weight of 25 plants were 6.2 ± 1.2 g and 75.5 ± 14.35 g at Rameswaram and Ervadi respectively,
6. The maximum extension growth rate (based on bushiness) was found to be 16.35 cm/month at Rameswaram and 133.44 cm/month at Ervadi, while the maximum growth rate (g/g/month) was 1.95 and 1.75 for Rameswaram and Ervadi respectively,
7. The maximum decapitation was 26% at Rameswaram while it was 52% at Ervadi,
8. The maximum secondary rhizoidal branch production was 31% at Rameswaram and 22% at Ervadi, and
9. The maximum tetrasporic plants were found to be 47% at Rameswaram and 63% at Ervadi.

From the study of natural growth, growth cycles have been determined and consisted of a single growth cycle (12 months duration) at Rameswaram and the half yearly growth cycles (6 months duration) at Ervadi.

Under agar ecology, the yield and physical properties of agar, viz. gel strength, gelling and melting temperatures of the monthly samples were determined. The agar characteristics of the materials from both the habitats are given as : (1) at Rameswaram, maximum agar content 47%, maximum gel strength 317 g/cm^2. gelling temperature 48.5^{0}C and melting temperature 90.5^{0}C ; (2) at Ervadi, maximum agar content 46%, maximum gel strength 249 g/cm^2, gelling temperature 46^{0}C and melting temperature 85.5^{0}C. In the lagoon habitat, the maximum agar formation is delayed by 6 months after the peak period of vegetative growth, while in the open shore habitat it is maximum during the peak period of vegetative growth itself. The agar content and physical properties, although show some differences, were still found to be statistically non-significant between the habitats.

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Based on the growth cycles and agar ecology of *G. acerosa* in both the habitats, harvest may be recommended during January-March. Agar content and the physical properties have been found to be influenced by the environment and should be considered for fixing the time of harvest in order to get a crop with maximum agar content and physical properties.

In the growth regulator pretreatment experiments the optimal levels of common growth regulators effective in enhancing the growth have been determined : 100 mg/1 for kinetin, ascorbic acid and naphthalene acetic acid; 1 mg/1 for Indole 3-acetic acid and 10 mg/1 for Gibberellic acid. The effect of these growth regulators on height, percentage cover (spread) and percentage rhizoid production, in some cases crop yield and agar characteristics were studied. All the parameters studied showed enhancement in each of the growth regulator pretreatment. Taking the overall effect GA, induces more extension growth and percentage crop yield. GA and IAA produce more spread (cover). AA and NAA are effective in producing height, rhizoid formation and spread to an optimal level. Based on the effect on growth parameters as well as on agar content, ascorbic acid pretreatment is recommended to improve growth in the field cultivation.

In the transplantation experiments, reverse transplants were made between the two habitats with a view to understanding the nature of forms Growth in height, crop yield, and agar content are studied. The results established that the open shore form continues to exhibit the enhanced growth in biomass (crop yield) and in growth rate and ultimately the agar content, when transferred to the lagoon habitat. When transferred to open shore habitat the changes in the lagoon form in height and agar content are immediate, although increase in growth rate or crop yield are not produced. On the available data obtained from the reverse transplants, the two forms from the two different habitats are classified as growth forms showing phenotypic differences. The open shore form appeared to have been evolved as an adaptation to the environment and got stabilised. The phenotypic differences are prominent in the open shore form at Ervadi by the bushy and spreading growth of plants with more number and advanced type of branch systems.

As *G. acerosa* natural resources in the Mandapam region have been subjected to repeated and indiscriminate harvests for more than a decade, proper management of its resources has assumed paramount importance today. The extent and type of harvest should be chosen

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so as to get maximum harvest, while allowing proper regrowth of crop. The earlier studies on regrowth and regeneration pointed to full recovery only after 6 months interval. However, no information is available on differential harvests and recovery period. The present study was designed to fill this gap. Differential harvests of three types, viz. complete, moderate and discrete (hand picking) were made during the peak period of vegetative growth and the time taken for recovery was noted by studying the regrowth of harvested population at bimonthly intervals at Ervadi. The results indicate a short recovery period of 8 months in moderate harvest in comparison with 12 months period required both in complete and discrete harvests. Considering the overall recovery, moderate harvests are recommended. Commercial harvesting as it is practised now more often denudes the beds by uprooting the plants altogether. This is outside the perview of the present work and by common knowledge should not be allowed. Based on the findings of present study, a harvesting time table may consider harvests once in 8/12 months period depending on the degree and time of harvest.

STUDIES ON SOIL RESPIRATION AND ROOT DECOMPOSITION IN A WHEAT-MAIZE ROTATION CROPLAND AT VARANASI

Chandra Shekhar Sup : *Dr. K. P. Singh*

1. The present investigation deals with biomass and nutrient relations, soil respiration and root decomposition of wheat and maize crops during one year period. The study was conducted in an experimental plot at Banaras Hindu University (25°18'N lat. and 80°1' E long., 76 m above mean sea level).

2. Wheat seeds were sown on 7 December 1979 and of maize on 22 June 1980. The wheat and maize density was maintained at 25 and 4 plants m^{-2}, respectively. Samplings for biomass and soil respiration were done fortnightly and for root decomposition monthly.

3. The live shoot biomass increased considerably with advancing age reaching to 1580 $g.m^{-2}$ and 1563 $g.m^{-2}$ for wheat and maize crop, respectively, at crop maturity. The standing dead appeared at 75 days age of both crops and increased till crop harvest (105 days wheat and 90 days maize). The belowground biomass increased till 75 days age

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of wheat and decreased thereafter. However, during maize crop after an initial increase till 30 days root biomass followed a less regular pattern. Its contribution towards total biomass at maturity was 6.8% and 4.8% in wheat and maize, respectively.

4. Aboveground net production (ANP) was minimum at 15 days age (0.22 $g.m^{-2}$ day^{-1} and 0.43 $g.m.^{-2}$ day^{-1} in wheat and maize crops), and maximum at 75 days age in both crops. The belowground net production (BNP) increased till 45 and 75 days in wheat and maize crops. Total net production (TNP) was maximum at 75 days in both crops (928 $g.m^{-2}$ and 1103 $g\ m^{-2}$ during 60-75 days in wheat and maize, respectively).

5. Production ratios revealed that greatest transfer of material occurred from TNP to ANP (93% in both crops). On the contrary, least transfer occurred from TNP to TD (total disappearance).

6. Nitrogen and phosphorus concentration decreased in all plant parts with advancing age except in ear increased which showed continuous increase in nitrogen concentration. Similar results were obtained in case of potassium concentration also. Nitrogen content increased till 90 days in wheat and till maize crop maturity, however phosphorus and potassium content were maximum at 75 days in both crops. Maximum uptake of nitrogen, phosphorus and potassium occurred between 60-75 days in both crops.

7. The seasonal pattern of total soil respiration (TSR) in field and top 10 cm soil core respiration (SCR) indicated maximum carbon dioxide evolution rates during maize crop period followed by wheat, summer fallow and pre-winter fallow periods. The annual TSR output in field was 1575 g $CO_2.m^{-2}yr^{-1}$. The time course variation in field TSR and SCR were significantly correlated both seasonally as well as annually.

8. Changes in root respiration with time in both crops were significant. Root respiration increased till 60 days age in both crops and decreased thereafter. Root free soil respiration rates were maximum during maize crop period followed by summer fallow, pre-winter fallow and wheat crop period.

9. The sum of root and root free soil respiration was less than SCR throughout the study period, ranging from 71% to 95% of SCR. Maximum contribution by root towards SCR during wheat crop (26%) occurred at 60 days and during maize crop (24%) at 45 days age. The contribution of root free soil towards SCR was maximum (77%) during pre-winter fallow and minimum during wheat crop period.

10. The soil moisture had a limiting effect on carbon dioxide evolution rates. Soil moisture explained 57% and 42% variability in

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TSR and SCR rates. Temperature variations explained 35% and 24% variability in TSR and SCR rates. Rainfall accounted for 35% and 73% variation in TSR and SCR rates.

11. A linear combination of mean daily air temperature, soil moisture and rainfall fitted in a multiple regression explained 62% variability in TSR rate during whole study period. The output of the model simulated the observed rates in important aspects and showed 65% comparability between the observed and calculated values.

12. The time series data on percent weight remaining in wheat and maize root material showed differences in magnitude of weight loss from both mesh size bags (coarse, 1 mm pore size and fine mesh, 0.003 mm) In maize weight loss differed in these bags at two soil depths (5 and 12.5 cm). The total weight loss in root bags were : maize root (during 214 days), at 5 cm depth, 79% and 50% in coarse and fine mesh bags; at 12.5 cm depth, 97% and 60% in coarse and fine mesh bags; wheat root (during 275 days), at 5 cm depth, 72% and 45% in coarse and fine mesh bags.

13. The carbon dioxide evolution rates from decomposing roots observed significant positive relationship with weight loss.

14. The maize and wheat root relative decomposition rates (RDR) in all instances rapidly increased through initial few months and declined during subsequent months. During the first four months the maize root RDR at 12.5 cm depth bags exceeded that at 5 cm depth bags Coarse mesh RDR was always higher than that of fine mesh bags.

15. Nitrogen (N) and phosphorus (P) concentrations, after an initial decrease during first few months, increased in all instances. Concentration of N and P was always higher in fine than in coarse mesh bags and higher in maize roots buried at 12.5 cm depth. Irrespective of increase in concentration, the absolute amount of N and P decreased in all instances due to overriding influence of weight loss over concentration increase.

16. The two major environmental variables, temperature and soil moisture had significant positive relationships with rate of wheat root decomposition; but negative correlations were observed between these environmental variables and maize root decomposition rates.

17. The balance sheet of input and output of organic matter/carbon indicated that the carbon output calculated through root bag studies and total disappearance (ANP + root disappearance) was relatively closer to carbon input estimate. The output calculated through soil respiration was only 73% of the input values.

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CHEMISTRY

Ab initio Mo CALCULATIONS OF *esr* HYPERFINE COUPLINGS

Shashi Ranjan Prasad Karna Sup. : *Dr. P. Chandra*

This thesis deals in the evaluation of the esr hyperfine couplings. These hyperfine couplings arise due to the interaction between the magnetic moment associated with the spinning electron and the nuclear magnetic moment, (S. I.), and are experimentally observed as the centro-symmetric splittings of the esr spectra of organic and inorganic radicals and certain ions. These hyperfine splittings consist of two parts :

(i) One that arises because of the interaction of the spherically symmetric electronic charge distribution at the site of the nucleus with the nuclear magnetic moment and is referred to as the isotropic hyperfine coupling constant.

(ii) The other arises because of the interaction of the electron magnetic-dipole and nuclear magnetic dipole and is orientation dependent. Because of its dependence on the spatially non-symmetric orbitals, it is called the 'anisotropic hyperfine coupling' and is a traceless tensor.

In gas or solution phase, the anisotropic hyperfine interaction averages out to zero because of rapid tumbling of the molecules and only isotropic couplings are observed. But in a solid host, the radicals exhibit the anisotropy in the hyperfine couplings.

We have used *ab initio* MO method to calculate these hyperfine couplings in CH, OH, NH, NH_2, HCN^-, HOO, CH_3 and NH_3^+ radicals. This thesis, which is divided in to three chapters, embodies the results of this calculation. In the First Chapter, a brief historical survey of the hyperfine couplings along with the LCAO-MO for the SCF theory in UHF formalism to construct a single determinent total molecular wave function obtained as antisymmetrized product of the MO's are discussed. The expressions for the hyperfine coupling constants, in terms of the 'spin density matrix' are given.

Bacause of the impracticability in the use of Slater type orbitals (STO's) for such calculations, we have used the Gaussian Type Orbitals

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(GTO's). Chapter 2 describes the linear combination of the Gaussian Orbitals (LCGO) to be used in molecular calculations. Molecular integrals over Gaussian functions, similar to those of Taketa *et al* have been derived and are given in this chapter. A general expression for the operator $< \frac{1}{r_{1c}} >$ and its derivatives has been obtained to be used for the evaluation of the nuclear attraction as well as the field gradient integrals. This expression evaluates the nuclear attraction integrals and the field gradient integrals over the s, p, d, f...atomic orbitals and not much additional programming effort is required in using higher angular momentum atomic orbitals. A brief account of the computer program coded by us is given in Chapter 2.

In our calculation, we have used the (9s 5p)/[3s 2p] and (9s 5p)/[4s 2p] on second row atoms and [4s/2s], [4s/3s] on hydrogen. But to test the suitability of a basis function for such calculations, larger basis sets have also been used.

Chapter 3 deals in the calculations for hyperfine coupling constants. Chapter 3 has two sections. In Section A the effect of different basis sets, on the energies and the hyperfine coupling constants has been described. Our calculations reveal that for such calculations the use of bond centered functions along with a double zeta (9s 5p)/[4s 2p] on second row atoms and [4s/2s] on hydrogen with ζ H = 2 is as good as a larger basis set, namely (10s 6p)/[5s 4p] and is recommended as a better basis set for one-electron property suce as hyperfine couplings. Our calculations also show that whereas isotropic hyperfine coupling constants are very sensitive to the basis set used, the anisotropic hyperfine couplings are rather insensitive. The reasons are explained and the discrepancies are justified. We have, however, for subsequent calculation used Dunning Jr., (9s 5p)/[3s 2p] basis on second row atoms and [4s/2s] basis on hydrogen, discussed in Section B of this chapter. In this section the results for molecular orbital energies, hyperfine couplings and the orientation of the principal axes of hyperfine tensor with respect to the molecular axes, are described. The total energies are very nicely reproduced and match (wherever available) with experimental and other *ab initio* calculations. The isotropic hyperfine couplings, in general, are only poorly represented whereas the anisotropic part of the hyperfine coupling are well produced and are even better than other *ab initio* calculations. Reasons of this failure in case of isotropic hyperfine coupling and success in case of anisotropic hyperfine coupling are attributed to the poor cusp behaviour of the gaussian functions. Moreover, since in the use of contracted gaussian

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functions, the coefficients of all the primitives of a contracted function are fixed once for all and hence there is little flexibility in such functions to explain the electron density in the close vicinity of the nucleus, resulting in a poor value of isotropic part of the hyperfine interaction. Possible improvements in the use of basis function is suggested.

STEREOCHEMISTRY OF THE COORDINATION COMPOUNDS OF METAL (II) SALTS WITH SOME NITROGEN AND OXYGEN DONORS

Chhote Lal Sup. : *Dr. I. S. Ahuja*

During recent years stereochemistry of coordination compounds formed by transition and non-transition metal salts with organic ligands containing one or more potential donor sites has been established through X-ray crystallography, magnetic susceptibility, electronic and infrared spectral measurements. Although X-ray diffraction patterns establish the structures of compounds unambiguously the utility of the technique is, however, limited because of the complications involved in the analyses of such patterns. On the other hand, qualitative analysis of i. r. spectra (especially the region below 600 cm^{-1}) is devoid of such complications. Thus, even though the crystal structure of a compound may not be known, the far i. r. spectral measurements of such a compound in conjunction with magnetic moments and electronic spectral data provide much valuable and definite information on its structure.

Magnetic measurements of transition metal compounds are of importance in solving problems of molecular structure and bond type because they afford a means of detecting the presence of singly occupied electronic orbitals. Electronic spectra of transition metal coordination compounds give information about the environment of the metal ion. Ligand field parameters such as 10 D_q, B, β and λ can be calculated from the interpretation of the absorption bands obtained in the electronic spectra. The magnetic susceptibility and electronic absorption spectroscopy yield unambiguous structural information of transition metal compounds.

Infrared respectra show the presence of the anions and of the ligand molecules in the complexes, and also, whether or not decomposition of ligand molecules has taken place or whether solvent molecules

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have been included in the solid compounds. Metral-halogen stretching vibrations occurring in the low frequency region, and which can easily be identified, provide valuable information regarding the oxidation state, coordination number of the metal ion and stereochemistry of the coordination number of the metal ion and stereochemistry of the coordination compound. With the availability of commercial double beam grating spectrophotometer capable of reaching down to at least 200 cm^{-1} much data have accumulated on metal-chlorine, metal-bromine and in some cases metal-iodine stretching vibrations. Besides metal-halogen frequencies, it is also possible to study ν metal-ligand (ν M-O, M-N, M-S, M-P etc.) modes an well as certain low frequency bending modes in the far i. r. spectral region. Furthermore, the far infrared spectroseopy finds a wider application in compounds where the metal ion has a closed shell of valence electrons (since magnetic susceptibility and electronic spectra are not possible for such systems).

Electron spin resonance (ESR), also called electron paramagnetic resonance (EPR) spectroscopy is based on the fact that atoms, ions, molecules, or molecular fragments that have an odd number of electrons exhibit characteristic magnetic properties. These arise from either the orbiting action or the spinning action, or both, of unpaired electrons about the nucleus. Unpaired electrons, relatively unusual in occurrence, may be present in molecules, free radicals. triplet electronic states, and transition element ions. An electron possesses a spin and associated with the spin there is a magnetic moment.

Electron spin resonance spectroscopy is concerned with the energy and local environment of unpaired electrons in atomic and molecular systems. Since the unpaired elecron is normally involved in the bonding of the atoms of the molecular system, E. S. R. provides a very sensitive probe for the detection and measurement of the effects of small changes in bonding and also serves as an experimental check upon the predictions of the theories of bonding. The limitations of E. S. R. include the requirement that the system has at least one unpaired electron, that the unpaired electron be in an environment such that the conditions of resonance occur over a small range of values so that the signal is not inhomogeneously broadened to the point that it is undetectable, and that the environment be such that the relaxation times are neither too long nor too short. In practice these three limitations restrict the applicability of E. S. R. measurements to only a small fraction of the known transition metal systems. However, from the systems that can be studied, E. S. R. is able to provide information which can be utilized in understanding the bonding in other transition metal systems.

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Photoacoustic spectrometry is a versatile technique of recording spectrum in the u. v. visible and i. r. regions of any of the solid or semi-solid material. A photoacoustic spectrum, however, corresponds only qualitatively to an optical absorption spectrum because the technique measures only the amount of absorbed optical energy de-excited through non-radiative processes. This qualitative agreement between the photoacoustic and optical spectra has been exploited in unambiguous identification of substances available in extremely minute quantities. This most successful and popular theory of photoacoustic effect is that due to Rosencwaig and Gersho (1976). They developed an exact equation for the magnitude and phase of the photoacoustic signal as a function of the optical, thermal and geometrical properties of the sample.

The greatest advantage of photoacoustic spectroscopy is the fact that no special preparations are required. Samples in the form of powders, gels, liquids, fibrous material, etc. can be studied with equal ease. The method is proving to be an extremely useful tool for investigations in the field of biology, medicine, surface studies and atmospheric pollution studies.

Several studies appear to have been made on the coordination compounds formed by transition and non-transition metal salts with the well known nitrogen and oxygen donor ligands. Structure of most of these have been established through X-ray crystallography and/or magnetic susceptibility, electronic and i. r. spectral measurements. Metal-ligand modes have been identified in low frequency i. r. spectra and correlated with the stereochemistries of the compounds.

Among the aliphatic heterocyclic ring systems, hexamethylene-tetramine affords an example which consists of three fused rings in the chair configuration with four bridge-bead nitrogen atoms. The chemical and steric equivalence of these four bridge-head nitrogen atoms has been demonstrated by various physico-chemical studies. It may thus act as a mono-, bi-, tri-or tetra-dentate ligand. However, till recently, it was known to act only as a bidentate bridging ligand. The present study on the coordination behaviour of hexamethylenetetramine with several bivalent metal salts has been undertaken. The compounds isolated show that in addition to its bidentate behaviour it may also act as a monodentate and a tetradentate ligand.

In addition to hexamethylenetetramine the donor abilities of a few pyridine derivatives have also been studied. The pyridine derivatives studied are in general, potentially bi-or tri-dentate ligands.

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2, 3-and 4-Benzoylpyridines are pyridine derivatives with a benzoyl group, $-COC_6H_5$, at 2-, 3-and 4-positions, respectively, in the pyridine ring. Each of these benzoylpyridines possesses two donor sites : (i) pyridine ring nitrogen, and (ii) the carbonyl oxygen of the benzoyl group. These pyridines are potential bidentate donors and have the skeletons N-C-C-O, N-C-C-C-O, and N-C-C-C-C-O, respectively, which have partial double bond/aromatic character.

Replacement of a proton for a pyridyl group at α – and χ positions in the pyridine ring would result in 2, 2′-bipyridyl and 4, 4′-bipyridyl, respectively. In other words, both 2, 2′-bipyrdyl and 4, 4′-bipyridyl consist of two pyridyl rings each one of which is substituted at a position ortho-to the other in 2, 2′-bipyridyl and para-to the other in 4, 4′ bipyridyl. Both these bipyridyls are potentially bidentate ligands. The chief difference in the donor ability of these two bipyridyls is that whereas 2, 2′-bipyridyl can act as a bidentate chelating ligand resulting in the formation of fine-membered rings (including the metal ion) the structure of 4, 4′-bipyridyl does not permit chelation but favours coordination of the two nitrogens to different metal ions, thus leading to the formation of polymeric chain structures.

The nitrogen atom of the pyridine ring has an additional prospect to react with peracids forming N-oxides. Thus oxidation of 2, 2′-bipyridyl and 4, 4′-bipyridyl may give rise to N-oxide or N, N′-dioxides. These N-oxides and N, N′-dioxides of pyridines, bipyridyls and their derivatives have a pronounced tendency to act as electron pair donors forming molecular adducts and complexes with a variety of acceptors such as metal salts.

The donor properties of 2-, 3- and 4-cyanopyridines have been the subject of several investigations. Special interest in the coordinating tendency of these ligands arises from the fact that each of these pyridines possesses two potential donor sites : (i) pyridine ring nitrogen, and (ii) the nitrile group—which raises the possibility of linkage isomerism and also provides an opportunity for comparison of bond strengths of the same ligand. Furthermore, the cyano group may also be involved in coordination through either (i) the cyano nitrogen on account of its available electron pair, or (ii) the triple bond or π-electrons.

Oxidation products of cyanopyridines offer interesting examples of bidentate ligands. Special interest in the coordination tendency of cyanopyridine N-oxide arises from the fact that it possesses two potential donor sites, i.e., (i) oxygen of the N-oxide group, and (ii) the nitrile group, which raises the possibility of linkage isomerism and also

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provides an opportunity for comparison of the bond strengths of the same ligand. Furthermore, the cyano group may also be involved in coordination through either (i) cyano nitrogen on account of its available electron pair, (ii) the triple bond or π-electrons.

Most of the ligands used in the present investigation are toxic and possess biological activities such as insecticidal, fungicidal, bacteriostatic, antitubercular etc. The toxicity of these compounds is due to a combination of basicity and surface activity and because of the latter property these compounds are able to alter the behaviour of cell membranes. Their action has been explained through the complex formation between DNA and the organic ligands.

In addition to establishing their stoichiometries the coordination compounds prepared in the present investigation have been characterized, where possible, by molecular conductance, molecular weight, room temperature magnetic moments and electronic spectral measurements. In each case their near and far i. r spectra down to 200 cm^{-1} have been examined for variations in the ligand spectrum, for bands possibly due to ν metal-halogen and ν metal-nitrogen/oxygen modes. In the case of nitrate, sulphate, acetate and thiocynate complexes variations in the i. r. spectra to elucidate the mode of metal-anion bondings. In some cases E. S. R. and photoacoustic spectra have also been recorded. On the basis of these physico-chemical studies the probable stereochemistries of the compounds in the solid state have been suggested. The techniques of magnetic susceptibility and ligand field spectroscopy, though they yield useful structural information on transition metal complexes are, however, not applicable to d^{10} systems (divalent zinc, cadmium and mercury compounds) as these have closed shells of valence electrons. Information on the tentative stereochemistries of their compounds in the present study has been derived from a comparison of metal-ligand and metal-anion bondings with similar modes in complexes whose structures have been established by X-ray crystallography and/or magnetic susceptibility, electronic and i.r. spectral studies.

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STEREOCHEMISTRY OF THE COORDINATION COMPOUNDS OF METAL (II) SALTS WITH SOME NITROGEN DONORS

Chandra Pati Rai Sup : *Dr. I. S. Ahuja*

During recent years stereochemistry of coordination compounds formed by transition and non-transition metal salts with organic ligands containing one or more potential donor sites has been established through X-ray crystallography magnetic susceptibility, electronic and infrared spectral measurements. Although X-ray diffraction patterns establish the structures of compounds unambiguously the utility of the technique is, however, limited because of the complications involved in the analysis of such patterns. On the other hand, qualitative analysis of i. r. spectra (specially the region below 600 cm^{-1}) is devoid of such complications. Thus, even though the crystal structure of a compound is unknown, the far i. r. spectral measurements of such a compound in conjunction with magnetic moments and electronic spectral data provide much valuable and definite information on their structures.

Magnetic measurements of transition metal compounds are of importance in solving problems of molecular structure and bond type because they afford a means of detecting the presence of singly occupied electronic orbitals. Electronic spectra of transition metal coordination compounds give information about the environment of the metal ion. Ligand field parameters such as 10Dq, B, β and ν_2/ν_1 can be calculated from the interpretation of the electronic absorption bands obtained in the electronic spectra. The techniques of magnetic susceptibility and electronic absorption spectroscopy though yield unambiguous structural information of transition metal complexes are, however, not applicable to complexes involving d^{10} systems.

Infrared spectra show the presence of the anions and of the ligand molecules in the complexes, and also, whether or not decomposition of ligand molecules has taken place or whether solvent molecules have been included in the solid compounds. Metal-halogen stretching vibrations occuring in the low frequency region, and which can easily be identified, provide valuable information regarding the oxidation state, coordination number of the metal ion and stereochemistry of the coordination compound. With the availability of commercial double beam grating spectrophotometers capable of reaching down to atleast 2 0 cm^{-1} much data have accumulated on metal-chlorine, metal-bromine and in some cases metal-iodine stretching vibrations. Besides metal-halogen frequencies, it is also possible to study metal ligand (M-O, N-N, M-S, M-P etc.) modes as well as certain low frequency bending

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modes in the far i.r. spectral region. Furthermore, the far infrared spectroscopy finds a wider application in compounds where the metal ion has a closed shell of valence electrons (since magnetic susceptibility and electronic spectra are not pssible for such systems).

The present thesis comprises of two parts. Part I begins with general introduction as Chapter I in which literature on the coordination chemistry of divalent cobalt, nickel, copper, zinc, cadmium and mercury has been summarized. The utility of the physico-chemical techniques such as magnetic susceptibility, electronic and i. r. spectroscopy down to 200 cm^{-1} in the elucidation of the stereochemistry of the coordination compounds has also been reviewed. Coordination compounds formed by some divalent manganeese, cobalt, nickel, copper, zinc, cadmium, mercury and monovalent silver salts with some nitrogen and oxygen donor ligands—1,3-bis (4-pyridyl)-propane, nicotinic acid, nicotinamide, isonicotinamide and N-methylnicotinamide, 4,4'-bipyridyl, 2,2'-pipyridyl, 1,10-phenanthroline, 2,2'-bipyridylamine and 2,2'-bipyridyl N,N'-dioxide—are described in Chapters II-IV. Most of the ligands used possess biological activities such as insecticidal, fungicidal, bacteriostatic etc. Probable stereochemistries for these compounds in the solid state have been deduced from their molar conductance, magnetic susceptibility, electronic and infrared spectral measurements down 200 cm^{-1} and from a correlation of the fundamental ligand modes and the metal-ligand modes with similar modes in compounds of proven structures.

The coordination chemistry of pyridine and its ring substituted alkyl and dialkyl derivatives has been sfudied extensively. Substitution of a $C_6H_4N(CH_2)_3^-$ group for a hydrogen atom in pyridine at 4-position would result 1,3-bis (4 pyridyl) propane. This molecule consists of two pyridyl groups both bonded in ν–position to the two terminal carbon atoms of propane and may act as a mono—or bidentate ligand. Molecular and scale model show that the geometry of 1,3-bis (4 pyridyl) propane remotes the two pyridyl rings from each other (C_2v symmatry, with two rings in one and the same plane or Cs when the two rings are non-planar). Such configuration would not permit chelation. Coordination of the two pyridyl nitrogen atoms to different metal ions would thus be favoured, resulting in polymeric chain structures. It was, therefore, considered of interest to study the coordination behaviour of 1, 3-bis (4 pyridyl) propane. Preparation and tentative stereochemistries of 1, 3-bis (4-pyridyl) propane complexes with divalent manganese, cobalt, nickel, zinc, cadmium and mercury halides and pseudohalides are discussed in Chapter II.

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Substitution of a COOH-group for a hydrogen atom in pyridine 4-position would result nicotinic acid. Substitution of a $CONH_2$-group for a hydrogen atom in pyridine at 3-and 4-positions and substitution of a $CONHCH_3$- group in pyridine at 3-position would give nicotinamide, isonicotinamide and N-methylnicotinamide, respectively. Nicotinic acid, nicotinamide, isonicotinamide and N-methylnicotinamid are potential bidentate donors and the donor sites are (i) pyridine ring nitrogen and (ii) carboxyl oxygen in nicotinic acid or carbonyl oxygen in the case of nicotinamide, isonicotinamide and N-methylnicotinamide. The partial aromatic character of these linkages (N-C-C-C-O in nicotinic acid, nicotinamide and N-methylnicotinamide, N-C-C-C-C-O in the case of isonicotinamide) and the fixed geometry of the donor sites are likely to play an important role on the donor ability of these molecules. Preparation and the problabe stereochemistries of the coordination compounds formed by nicotinic acid, nicotinamide and isonicotinamide with copper (II), chloride, bromide, thiocyanate and sulphate are reported in Chapter III Section A. Coordination compounds formed by nicotinic acid, nicotinamide and N-methylnicotinamide with mercury (II) chloride, bromide, cyanide and thiocyanate and their probable stereochemistries are given in Chapter III Section B

Substitution of a pyridyl group for the hydrogen atom in pyridine at 4-position would result in 4,4′-bipyridyl. This molecule is a bidentate ligand and provides the aromatic linkage N-C-C-C-C-C-C-N in which the donor sites (nitrogen atoms) are far apart from each other. The geometry of 4,4′-bipyridyl, therefore, precludes chelation but favours coordination of the two nitrogen atoms to different metal ions leading to the formation of polymeric chain structures. Coordination compounds formed by 4,4′-bipyridyl with cobalt (II), nickel (II), zinc (II), cadmium (II) and monovalent silver nitrates are discussed in Chapter IV Section A. Substitution of a pyridyl group for the hydrogen atom in pyridine at 2-position would give 2,2′-bipyridyl with the skeloton N-C-C-N 2,2′-Bipyridyl N,N′-dioxide, the oxidation product of 2,2′-bipyridyl provides two terminal oxygens with the skeleton O-N-C-C-N-O as the donor sites. 2,2′-Bipyridyl, 1,10-phenanthroline, 2,2′-bipyridylamine and 2,2′-bipyridyl N,N′-dioxide have two potential donor sites. Both the donor sites are bonded to the same metal ion (chelating ligands), resulting in the formation of five-membered ring in the case of 2,2′-bipyridyl and 1,10-phenanthroline, six-membered in 2,2′-bipyridylamine and seven-membered in case of 2,2′-bipyridyl N,N′-dioxide. Coordination compounds formed by 2,2′-bipyridyl, 1,10-phenanthroline, 2,2′-bipyridylamine and 2,2′-bipyridyl N,N′-dioxide with siiver (I), zinc (II) and cadmium (II) nitrates are described in Chapter IV Section B.

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Part II of the thesis classed as Chapter V begins with the general introduction in which literature on the chemistry of uranium (VI) has been reviewed and the subsequent sections describe coordination compounds of some uranyl salts with 2-methylbenzothiazole and hexamethylenetetramine. 2-Methylbenzothiazole is a potentially bidentate ligand having two donor sites, nitrogen and sulphur in the thiazole ring. Chapter V Section A describes coordination compounds formed by 2-methylbenzothiazole with uranyl chloride, nitrate and sulphate. Hexamethylenetetramine is a heterocyclic system having three fused rings in the chair configuration with four bridge head nitrogen atoms. It is a potentially tetradentate ligand and the chemical and steric equivalence of the four nitrogens have been demonstrated by various physicochemical studies. It may act as a mono-, bi-, tri-or tetradentate ligand. Frame work molecular models show that it is more likely to bond to different metal ions and thus act as a bridging rather than a chelating ligand. Coordination compounds formed by hexamethylenetetramine with uranyl, sulphate, nitrate and thiocyanate constitute Section B of Chapter V. The probable coordination arrangement around UO_2^{+2} group or urauium (VI) for all the new compound are discussed.

BIOCHEMICAL STUDIES ON THE EFFECTS OF DAUNOMYCIN AND RADIATIONS ON HUMAN PLACENTA DNA

Mridula S. Ranade Sup : *Dr. S. Srinivasan*

Great advances in drug therapy and the development of clinical pharmacoloy in the intervening years have increased the chances of exposure of man towards various drugs. Though effects due to drugs can be at different levels like membranes or enzymes, the effects on nucleic acid is of importance because of dominant influence of DNA over the processess of cell growth, division and differentiation and for genetic continuation. Anticancer antibiotics like daunomycin belong to the group of drugs which are known to interact physically with DNA. As there are many evidences to support the statement that interference with DNA in almost any conceivable way is likely to serve as prelude to the induction of cancer, the study of drug daunomycin with DNA becomes of greater importance. Other well known agents which are known to interact with DNA are radiations. Radiations and drugs seem to converge at the level of molecular mechanism therefore together with drug daonomycin, Co-60 gamma irradiation is chosen for the

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study. A dose of 600 krads of gamma irradiation and saturation ratio of daunomycin to DNA is used in all the cases for studying the effects of gamma irradiation and daunomycin on HPDNA.

Five major methodologies were employed in the study of the effects of daunomycin and gamma radiation on Human placenta DNA.

1. *Fluorescence intensity measurements of ethidium bromide binding sites on the DNA* :

Dye ethidium bromide intercalates into the double stranded regions of DNA and there is a definite number of sites depending upon the DNA, even though the exact specificity for EB binding is not known. The number of EB intercalation sites is an index of the extent of base pairing in the nucleic acid. The consequence of EB intercalation in DNA is an enormous increase in the fluorescence intensity. this property is put to advantage and the fluorescence emission intensity at 584nm (peak emission wavelength) was measured with increasing additions of nucleic acid to EB. The experimental procedure and estimation of number of binding sites on DNA are essentially according to LePecq and Paoletti and Waring with modification by Srinivasan Jaspars (1, 2, 3). Table I summarizes data from fluorescence studies for determination of EB binding sites on native HPDNA, HPDNA irradiated to 600 krads of gamma irradiation, HPDNA-daunomycin complex and heat denatured HPDNA. Also included in the table are binding constants for the EB intercalation.

2. *Spectral studies* :

Spectra of EB-HPDNA complex and daunomycin-HPDNA complex were measured and analysed in the visible region. The absorption peak of EB at 480 nm is shifted to longer wavelengths (bathochromic shift) upon addition of increasing amounts of HPDNA along with a decrease in the absorbancy itself (hypochromic shift), the spectra being characterized by an isosbestic point. Similarly addition of HPDNA to daunomycin results in a bathochromic shift and hypochromic shift characterized by an isosbestic point. The salient features from these spectra are summarized in Table II.

3. *Hyperchromicity studies* :

The increase in the optical density of a DNA solution following heating of the nucleic acid solution due to rupture of hydrogen bonded base pairs and base stacks is known as hyperchromicity. The method has been put to quantitative use in the estimation of extent of helicity in nucleic acids (4, 5). Table III summarizes the data obtained from these studies.

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4. Hydrogen ion titration studies :

The number of hydrogen ions available for titration in a nucleic acid depends on the molecular configuration. These titration studies were carried out essentially according to Sheele Lauffer (6) Srinivasan and Lauffer (7), Sharma and Srinivasan (8) and consists in adding titrant HCl to HPDNA in 0.1 M KCl followed by measurement of pH. From the volume and concentration of titrant added, the volume and concentration of HPDNA titrated and the resultant measured pH it is possible to calculate the equivalents of acid bound or released per 4 g atom of phosphorus in the nucleic acid. The titration curves with pH on the x-axis and equivalents of acid bound per 4 g atom phosphorus on the y-axis show that the curves are shifted towards higher pH values as follows : Heat denatured HPDNA > irradiated HPDNA > HPDNA-daunomycin complex. Table IV shows the salient features from these titration graphs.

5. Radioactive C-14 tryptophan binding studies :

Aromatic amino acids bind more to single stranded regions than to double stranded regions (9, 10). The extent of tryptophan binding with HPDNA was studied by addition of a known quantity of C-14 radioactive typtophan to HPDNA samples followed by alcohol precipitation, centrifugation and measurement of radioactivity in pellet by liquid Scintillation Counting.

The data from estimation of ethidium bromide sites studies contained in table I show that irradiation or daunomycin treatment of HPDNA results in loss of hydrogen bonded base pairs of nucleic acid as indicated by the reduction in the EB binding sites. Reduction in hydrogen bonds is more in the irradiated DNA than for the daunomycin treated DNA. Additionally the intrinsic association constants in table I point to different sites of binding for EB and daunomycin with HPDNA.

Spectral data show that the hypochromic and bathochromic shifts as well as the isosbestic point are altered concomittant with either irradiated or daunomycin intercalation of HPDNA. These spectra, especially are indicative not only of the extent of EB binding but also of conformation changes. In this regard they provide additional information over the EB-binding data discussed above. The data on hyperchromicity show that the hyperchromicity of the irradiated DNA and daunomycin complex are nearly the same and much less than that of native DNA. But the hypochromic shift of DNA-daunomycin complex is significantly less than that of irradiated DNA which inturn

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is less than that of native DNA. Additionally the bathochromic shift and isosbestic point of daunomycin-HPDNA complex are significantly different from those of either native DNA or irradiated DNA. All these taken together reveal that daunomycin complexing of the DNA results in conformational changes of DNA in addition to decrease in the extent of dye EB binding.

Titration of nucleic acid can reveal useful information on the extent of availability of hydrogen atoms for titration and therefore on the conformation of nucleic acid. In nucleic acid in pH range 3 to 7 the $-NH_2$ groups of bases take part in titration. Any change in the electrostatic environment of these groups can be detected from the titration curves of DNA.

Examination of data contained in Table IV shows that equivalents of acid bound at pH values of interest namely between pH 3.5 and 5.0 is maximum for head denatured HPDNA with progressively less values for irradiated HPDNA, HPDNA-daunomycin complex and native HPDNA in this order. These data are in good agreement with data from EB binding studies.

Data from amino acid binding studies show that irradiation of DNA as well as daunomycin complexing of DNA results in increase in radioactive C-14 containing tryptophan binding to DNA suggesting an exposure of bases with which the amino acid is known to interact.

In summary, daunomycin complexing of HPDNA or irradiation of HPDNA results in debase pairing, debase stacking and change in the charged characteristics of DNA. Eventhough at molecular level irradiation of the DAN and drug interactions are similar there are minor but perceptible differences in configurational characteristics.

TABLE I

Summary of EB-Bindfng Data

Sample	Number of EB-binding sites	Association Constant ($\times 10^5 M^{-1}$)
Native HPDNA	21.7±0.8 [3]	7.6±0.62 [3]
HPDNA-Daunomycin	17.2±0.6 [4]	8.1±0.73 [4]
Irradiated HPDNA	13.0±0.5 [3]	6.8±1.00 [3]
Heat Denatured HPDNA	10.8±0.8 [2]	5.0±0.35 [2]

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The number in square brackets refers to the number of individual experiments.

TABLE II

Complex	Hypochromic shift period	Bathochromic shift (NM)	Isosbestic point (NM)
Native HPDNA-EB	0.33	480 to 515	510
(HPDNA-Daunomycin)-EB	0.21	480 to 505	505
Irradiated HPDNA-EB	0.28	480 to 510	510

TABLE III

Summary of Hyperchromicity Data

Sample	Hyperchromicity at 260 NM
Native HPDNA	0 240 ± 0 01 [8]
Irradiated HPDNA	0.151 ± 0 01 [4]
HPDNA + Daunomycin Complex	0.149 + 0.002 [5]

The number in square brackets refers the number of individual experiments.

TABLE IV

Summary of Titration Data

pH	Increase in Equivalents of Acid Bound/4 Gram Atom of Phosphorus with respect to Native DNA		
	Daunomycin HPDNA	Irradiated HPDNA	Heat Denatured HPDNA
3.5	0.50	1.10	1.30
4.0	0.40	1.05	1.25
4.5	0.20	0.95	1.20
5.0	0.15	0.82	1.12

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PHYSICO-CHEMICAL INVESTIGATIONS ON CALCIUM ALUMINATE CEMENTS—CALCIUM DIALUMINATE

Upendra Kumar Mandal Sup. : *Dr. V. K. Singh*

The physico-chemical investigations on calcium aluminate cement have been carried out in the following steps :

Formation Kinetics :

Calcium dialuminate has been prepared by taking 1:2 molar proportion of calcium carbonate and aluminium oxide at 1410, 1460, 1500 and 1560°C. Reaction mixes were heated for different reaction times and unreacted lime were determined using glycerol-ethanol as solvent and ammonium acetate as titrant (having phenolphthalein indicator). The pink colour indicates presence of unreacted lime. Different phases formed have been studied by X-ray diffraction analysis. It was observed that lime is quickly utilized at all the temperatures and C_3A. $C_{12}A_7$, CA and CA_6 are formed alongwith the equilibrium phase CA_2. The relative amount of different phases and the change in their concentration with time has been plotted. Quantitative analysis of Calcium dialuminate formed was done by taking the peak at $2\theta = 25.4^o$ ($d = 3.50$) as a measure of amount of CA_2 formed. During the course of reaction, various phases disappear and CA_2 is left as ultimate reaction product. The equation chosen is,

$$1-(1-x)^{1/3} = K\,\text{Int}$$

The rate constant, K, was calculated and activation energy has been determined.

The activation free energies and entropies were calculated at different temperatures using the equation.

$$\triangle G^* = RT\left(\ln \frac{RT}{Nh} - \ln k\right), \text{ and}$$

$$\triangle S^* = (Q - \triangle G^*)/T$$

2. *Sintering :*

Sintering study of calcium dialuminate (-40 micron particle sizes) has been carried out at 1400, 1430, 1460 and 1485°C for 5 to 240 minutes soaking periods. Sintered product was studied by comparing the X-ray diffraction pattern with that of 100 percent CA_2 formed. Shrinkage values were measured. Log-log plot of shrinkage and time indicated grain boundary diffusion as the mechanism of sintering. Utilizing the equation,

$$\frac{\Delta L}{Lo} = \left[\frac{50b\,\nu\,a^3 D_B t}{7\pi k T r^3}\right]^{0.31}$$

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(of Johnson and Cutler), the grain boundary diffusion coefficients were calculated. Activation energy has been determined from Arrhenius plot.

Sintering study of mixes of calcium dialuminate and calcium monoaluminate have been carried out by taking –40 micron particles of each. Different mixes in the weight percent ratio of 3:11, 4:10 and 5:8 of CA_2 and CA have been sintered at 1320, 1360, 1500 and 1420°C for 5 to 240 minutes. The shrinkage and bulk density values were determined. To study the kinetics of sintering, the empirical equation D - K logt + C was utilized Plots of bulk density versus log sintering time shows a linear relationship with slope of K. K value was taken as a measure of rate constant at different temperatures and activation energy was calculated by the Arrhenius plot. The ratio of CA and CA_2 after sintering was studied quantitatively in various mixes using X-ray diffraction analysis.

3. Microstructural Study :

Formation of CA_2, sintering of CA_2 and sintering of CA_2 and CA mixes have been studied by taking microphotographs of samples using optical and electron microscope. Particle size distribution of –40 micron CA_2 was also studied using microscopic method.

4. Mixes and Castables :

The hydration study of CA_2, CA and 5 : 8 CA_2—CA and 5 : 8 CA_2—CA with Al_2O_3 (1 : 3) were done at 20°C. The samples were allowed to hydrate for 7 days and hydration products were studied using X-ray diffraction analysis by comparing the d values with standard values. The mixes produced Al $(OH)_3$ and CAH_{10}, C_2AH_8 and C_3AH_6. With increase of CA_2 content, CAH_{10} was the maximum hydration product whereas with the increase of CA content, C_3AH_6 was the maximum in hydration products.

CA_2, CA and CA_2—CA 5 : 8, CA_2—CA 7 : 6 were mixed with alumina in 1 : 3 mix ratio of cement and aggregate. They were cured for 7 days and samples were fired at 1460°C for 2 hours. After firing their X-ray diffractographs were taken to identify the various phases. All mixes had unreacted alumina. CA_6 became the dominating phase and some CA_2 was left in all the mixes.

Some castable compositions were prepared by taking mixes of CA_2 and CA as cementitious constituents and alumina as aggregate. The hydraulic as well as fired strength after firing at 1460°C for 2 hours were determined. Both hydraulic and fired strength of CA_2, CA mixes increase with increase in CA content.

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The pyrometric cone equivalent of CA_2, CA and CA_2—CA in the the weight percent ratio of 10 : 3, 8 : 5, 6 : 7, 5 : 8, 4 : 10 and 3 : 11 mixes were determined using Indian Standard Method. With increase in CA_2 content, i.e. with increase of Al_2O_3 content, P. C. E. value is increasing.

STUDIES ON SOME ASPECTS OF HETEROGENEOUS CATALYSIS

Amalesh De Sarkar Sup. : *Dr. S K. Bhattacharya*

The thesis entitled "Studies on some Aspects of Heterogeneous Catalysis" is broadly divided into two parts. Part I of the thesis deals with the studies on physico-chemical properties of some catalytically active molybdate, tungstate and chromate catalysts. Part II of the thesis deals with the studies on the heterogeneous catalytic vapour phase : (i) oxidation of toluene to benzaldehyde in fixed bed, under Section A, and (ii) oxidative dehydrogenation of ethyl benzene to styrene in fixed bed, under Section B.

A study of physico-chemical properties and the role of a catalyst in heterogeneous catalysis is of great importance. The molybdates, tungstates and chromates of transition metals and metals of the sub-group B of the Periodic Table have recently been reported as good catalysts from both theoretical and industrial standpoint. Literature survey reveals that not much work has been done on the structural characteristics of these catalysts. The importance of studying the physico-chemical properties of solid catalysts by using various modern techiques e. g., Thermal Analysis, X-ray Diffraction and Infra-red Absorption Spectroscopy, Electron Diffraction and Microscopy, ESR measurements, etc. in order to characterise the catalysts for their catalytic activity for evaluation of most active catalysts cannot be over-emphasised.

In part I of the thesis, the physico-chemical properties of the following catalysts have been dealt with : sodium molybdate, chromium molybdate, zinc molybdate, sodium tungstate, copper tungstate, zinc tungstate, tin tungstate, sodium chromate, silver chromate and nickel chromate.

This part of the thesis embodies preparation and chemical analysis of the above catalysts. Thermal characteristics of these systems have been studied by differential thermal analysis (DTA) and thermogravi-

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metric analysis (TG). The products obtained at different stages of thermal treatment following the thermal transitions have been identified by X-ray diffraction and infrared spectroscopy. Wherever possible, a correlation between structural characteristics of these catalysts and their catalytic activity has been attempted.

Sodium molybdate, during its thermal analysis, undergoes four endothermal changes at 160°, 470°, 643° and 689° which are due to dehydration, phase changes, crystal transformation and melting respectively. The catalyst exhibits its maximum catalytic activity within the range of 300-400°C. Thus the dehydrated catalyst shows catalytic activity. However, sodium molybdate belongs to an inactive class of catalysts having non-selective character as it does not present any significant IR band in 1000-900 cm^{-1} region.

Chromium molybdate shows in its DTA thermogram two endothermic peaks at 275° and 485°C followed by a sharp exothermic peak at 591°C. The endothermic peaks are due to dehydration and decomposition respectively, while the exothermic peak may be due to crystallization of the decomposed products. Chromium molybdate shows maximum catalytic activity around 350°C where the compound is completely dehydrated.

Zinc molybdate shows a series of endothermic peaks at 200°, 300°, 365°, 460° and 730°C in its DTA thermogram. The peaks at 200°, 300° and 365° are due to stepwise dehydration, the peak at 460°C may be due to phase change and that at 730°C due to decomposition. It is reported that this catalyst shows its activity within 300-500°C where the compound is more or less dehydrated.

Sodium tungstate in its DTA thermogram shows three endothermic changes at 150°, 600° and 700°C which are due to dehydration, crystal transformation and melting respectively. The catalyst is reported to be active within 250-510°C, where the catalyst is in completely dehydrated form.

The thermogram of copper tungstate shows one endothermic peak at 263.5°C due to dehydration, followed by an exothermic peak at 446.5°C due to crystallization. Maximum catalytic activity is reported to be around 260°C where dehydration is nearly complete.

The DTA thermogram of Zinc tungstate shows one endothermic peak at 170°C due to dehydration, followed by an exothermic peak at 360°C due to crystallization. The catalyst is reported to be fairly active within 250° to 350°C, thus the dehydrated compound serves the purpose of catalytic activity.

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Tin tungstate exhibits in its DTA thermogram an endothermic peak at 160°C due to dehydration. The exothermic peak at 345°C is due to decomposition. Two subsequent endothermic peaks at 615°C and 745°C may be due to phase changes of the decomposed products. Tin tungstate is reported to be active at 250-300°C, thus the dehydrated compound is responsible for the catalytic activity.

Sodium chromate undergoes four endothermic changes at 110°, 170°, 440° and 810°C. The endothermic changes at 110° and 170°C are due to stepwise dehydration, and that at 440°C may be due to phase change. At 810°C the compound melts. At 450°C, the compound is reported to be catalytically active; thus the dehydrated compound is having a new phase, which is responsible for its activity.

Silver dichromate in its DTA thermogram, exhibits three small endothermic peaks at 170°, 500° and 695°C. The endothermic peak at 170°C is due to removal of loosely held water molecules, and those at 500° and 695°C are due to phase changes. The compound shows its catalytic activity above 200°C. Thus, the completely dehydrated compound serves the purpose of catalytic activity.

In the DTA thermogram of nickel chromate two endothermic peaks at 170° and 415°C are observed. The endothermic peaks are due to stepwise dehydration. However, decomposition of this compound starts after 400°C. Thus the endothermic peak at 415° C may be due to dehydration and/or decomposition. It is reported that the catalyst shows its activity at about 350° C. Thus the dehydrated and decomposed products serve the purpose of catalytic activity.

In part II of the thesis studies on heterogeneous catalytic vapour phase oxidation of toluene to benzaldehyde using vanadium pentoxide, bismuth oxide, bismuth vanadate (2:3), chromium vanadate, copper vanadate, cerium molybdate, iron molybdate, and cobalt molybdate (supported and unsupported) catalysts in fixed bed is carried out under Section A, whereas catalytic vapour phase oxidative dehydrogenation of ethylbenzene to styrene using molybdates of iron, cobalt and nickel is carried out in fixed bed under Section B.

Benzaldehyde and styrene find wide uses in industry. Toluene and ethylbenzene are abundantly available from petrochemical and coal-chemical industries. Any simple, elegant and direct method for their preparations from toluene and ethylbenzene respectively is welcome from the chemical and technological point of view.

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Oxidation of toluene is carried out covering a wide range of operating variables like temperature 300-500°C, air-toluene mole ratio of 300-630 and space velocity of 5250-9987 litres/hour-litre. Among the molybdate catalysts, ferric molybdate is the most active which can convert toluene to 15.83 percent benzaldehyde, 3.52 percent benzoic acid, 6.45 percent maleic acid and 49 percent carbon dioxide with 21.16 percent selectivity to benzaldehyde at 400°C, air-toluene mole ratio of 520 and a space velocity of 6210 litres/hour-litre. Cobalt molybdate converts toluene to only 8.90 percent benzaldehyde, whereas pumice supported cobalt molybdate ($CoMoO_4$: Pumice = 80 : 20) shows a maximum conversion of 1..89 percent to benzaldehyde with a selectivity as high as 60.98 percent at 505°C, air-toluene ratio of 415 and a space velocity of 7800 litres/hour-litre.

Among the vanadate catalysts, chromium vanadate shows maximum activity, which can convert toluene to 7.35 percent benzaldehyde and 2.25 percent benzoic acid at 506°C, air-toluene mole ratio of 454 and a space velocity of 6791 litres/hour-litre. However, fused vanadium pentoxide is by far the most efficient catalyst which converts toluene to 19.50 percent benzaldehyde at 504°C, air-toluene ratio of 405 and a space velocity of 6311 litres/hour-litre.

Oxidative dehydrogenation of ethylbenzene to styrene is carried out covering, a wide range of operating variables like temperature 338-518°C, air-ethylbenzene ratio of 440-793, at the space velocity of 6634 litres/hour-litre.

Ferric molybdate shows a maximum conversion of 8.63 percent of ethylbenzene to styrene with a space time yield of 5.20 grams/hour-litre at 398°C, a space velocity of 6634 litres/hour-litre and an air-ethylbenzene ratio of 510.4. Physico-chemical properties of ferric molybdate by Bhattacharyya and co-workers revealed the presence of α-Fe_2O_3 and MoO_3 at about 400°C. Thus the maximum activity of iron molybdate is due to the presence of α-Fe_2O_3 and MoO_3 in the catalyst. Cobalt molybdate exhibits a maximum conversion of 6.60 percent to styrene with a space time yield of 2.60 grams/hour-litre at 398°C and air-ethylbenzene ratio of 783.2. Physico-chemical studies of cobalt molybdate by Bhattacharyya *et al* revealed the presence of CoO and MoO_3 around 400°C. Thus, maximum catalytic activity corresponds to the presence of CoO and MoO_3 in the catalyst. Among the molybdate catalysts, nickel molybdate is found to be the most active which is able to convert ethylbenzene to 9.68 percent styrene, with a space time yield of 4.16 grams/hour-litre at a temperature of

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422 C and an air-ethylbenzene ratio of 718.8. The results of the studies on physico-chemical properties of nickel molybdate by Bhattacharyya *et al* indicated that the dehydrated catalyst exists in the form of its component oxides, NiO_3 at about 420°C, which is responsible for the maximum catalytic activity of this catalyst.

Though the oxidative dehydrogenation of ethylbenzene to styrene is not very much promising with molybdates of iron, cobalt and nickel, these results are in very good resemblance with the results of the physico-chemical properties of these catalysts previously studied by Bhattachayya *et al.*

SOME FIRST ROW TRANSITION METAL COMPLEXES OF AROMATIC O-HYDROXYALDIMINES

Rudra Pal Singh Sup. : *Dr. R. C. Agrawal*

Because of the inadequacy or complete absence of previous work on 3d metal complexes of salicylaldehyde hydrazone (SH) salicylaldehyde picolinoyl hydrazone (H_2PIS), salicylidene ethyl carbazate (SEC), salicylaldazine (H_2SA), salicylaldoxime (H_2Salox) and o-hydroxynaphthaldoxime (H_2Nolox), it was thought of interest to undertake a systematic preparative and structural study of these complexes.

Preparation of the Complexes :

The adducts of the compositions $VO(SH)_3SO_4$, $M(SH)_4Cl_2$ [where M = Mn(II), Fe(II), Co(II), Ni(II), Cu(II) or Zn(II)] and $M(H_2PIS)_2Cl_2$ [where M = Mn(II), Co(II) or Ni(II)] have been obtained by mixing methamolic/ethanolic solutions of appropriate metal salts and ligands in ~1:2 molar ratio and stirring or refluxing the reaction mixture. The Fe(II) complex has been prepared under nitrogen atmosphere to prevent its oxidation.

1:2 deprotonated complexes have been prepared by mixing aqueous or alcoholic solutions of the metal chloride/sulphate and the appropriate ligands in~1:2 molar ratio followed either by the addition of one equivalent of aqueous/alcoholic KOH or by raising the pH to~6 by NH_4Cl-NH_4OH buffer. H_2Nolox complexes of VO(IV), Fe(II), Ni(II) and Cu(II), however, precipitated immediately on mixing aqueous or alcoholic solutions of the metal salts and ligands

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1:1 deprotonated complexes have been synthesized by mixing together aqueous solutions of the metal chloride and ethanolic solutions of the ligands in 1:1 molar ratio dissolved in two equivalents of aqueous or alcoholic KOH. The complexes VO(PIS). H_2O and Cu(HPIS)Cl. H_2O, however, precipitated immediately on mixing the methanolic or ethanolic solutions of vanadyl sulphate/copper chloride and H_2PIS.

The complexes have been analysed for metal, anion (chloride or sulphate), hydrazine by using standard literature procedures and nitrogen by microanalysis.

The structures of the complexes have been established with the help of molar conductance, magnetic susceptibility, electronic, IR, X-ray powder diffraction and ESR spectral measurements.

Analytical data show the formation of adducts as well as deprotonated complexes with SH and H_2PIS and only deprotonated complexes with SEC, H_2SA, H_2Salox and H_2Nolox having the following general compositions :

Adducts :

$M(SH)_4Cl_2$; M = Mn(II), Co(II), Ni(II), Cu(II) or Zn(II)
$VO(SH)_3SO_4$
$M(H_2PIS)_2Cl_2$; M = Mn(II), Co(II) or Ni(II).

Deprotonated complexes :

$M(L-H)_2.xH_2O$; M = VO(IV), Mn(II), Fe(II), Co(II), Ni(II), or Zn(II) ;
L = SH, H_2PIS, SEC or H_2Nolox ;
x = 0 or 2

$M(L-2H).xH_2O$; M = VO(IV), Mn(II), Fe(II), Co(II), Ni(II), Cu(II) or Zn(II) ;
L = H_2SA, H_2Nolox, H_2Salox or H_2PIS ;
x = 0, 1 or 2

$Cu(SEC-2H).H_2O$
$Cu(HPIS)Cl.H_2O$

Bispyridine Adducts :

$M(L-2H).(py)_2$; M = Mn(II), Ni(II) or Cu(II) ;
L = H_2Nolox, H_2Salox.

All the adducts, deprotonated complexes and their bispyridine adducts are insoluble in water and common organic solvents such as

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ethanol, acetone, chloroform, THF etc. but with few exceptions, soluble in DMF.

The molar conductances of the soluble complexes in DMF at 10^{-3}M dilution lie in the range 5-20 $Ohm^{-1}cm^2$ $mole^{-1}$ indicating their non-ionic nature. However, the molar conductivities of H_3PIS adducts falling in the range 40-45 $Ohm^{-1}cm^{-2}$ $mole^{-1}$ are too low for 1:1 electrolyte and indicate some ionic dissociation in DMF as shown below :

$$M(H_2PIS)Cl_2 \rightleftharpoons M(H_2PIS)Cl^+ + Cl^-$$

Magnetic susceptibility studies :

The magnetic moments of the majority of the adducts, deprotonated and bispyridine complexes of Co(II) (4.73 - 4.97)* and Ni(II) (2.97 – 3.33) are consistent with spin-free octahedral geometry around these metal ions.

The magnetic moments of Mn(II) and Fe(II) complexes lying in the ranges 5.70 – 6.10 and 4.9 – 5.05 respectively indicate that they are spin-free with octahedral/tetrahedral geometry. Compositions and IR spectral studies of these complexes, however, show that they are octahedral.

The μ_{eff} values of Cu(II) and VO(IV) complexes show the presence of one unpaired electron giving no information about their stereochemistry.

Electronic spectra

The electronic spectra of VO(IV) complexes, $VO(SH)_3SO_4$ and $VO(SA).H_2O$ are consistent with octahedral geometry for the former complexes and square pyramidal geometry for the latter.

The bands observed in the spectra of $Fe(SH)_4Cl_2$ and $Fe(SH\text{-}H)_2.2H_2O$ may be assigned to $^5T_{2g} \rightarrow {}^5E_g$ transition assuming octahedral symmetry around Fe(II).

The electronic spectra of all Co(II) and Ni(II) complexes except those of $Co(HNolox)_2$ and $Ni(HNolox)_2$ are consistent with octahedral geometry. Square planar geometry is suggested for $Co(HNolox)_2$ and $Ni(HNolox)_2$.

All the Cu(II) complexes of H_2SA, H_2PIS, H_2Salox, H_2Nolox and SH except $Cu(HNolox)_2$ and $Cu(SH\text{-}H)_2$ give a broad band in the region 13350 – 15400 cm^{-1} indicating distorted octahedral geometry tetragonally distorted. $Cu(HNolox)_2$, $Cu(SH\text{-}H)_4$ and $Cu(SEC-2H).H_2O$

* All magnetic moment values are in BM units.

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also give only one broad band but at a relatively higher frequency (15000 – 19050 cm^{-1}) suggesting square planar environment around Cu(II) ion.

Infrared spectral studies

The bonding sites of the aromatic o-hydroxyaldimines involved in their transition metal complexes have been determined from a careful comparison of the infrared spectra of the complexes in nujol with the chloroform solution spectra of the parent ligands to eliminate the effect of hydrogen bonding in the ligands.

(1) A negative shift of 10 – 17 cm^{-1} in ν(C = N), a positive shift of 20 – 30 cm^{-1} in ν(N – N) and practically no shift in νN – H in the spectra of SH adducts indicate bonding through only one of the nitrogens viz. azomethine nitrogen, suggesting thereby monodentate behaviour of the ligand.

(2) In the addition compounds of H_2PIS, the ligand shows a bidentate behaviour coordinating through carbonyl oxygen and pyridine nitrogen as is evident from the negative shift in amide I (55 - 70 cm^{-1}) and positive shifts in amide II (10 – 20 cm^{-1}) and amide III (5 – 10 cm^{-1}) bands coupled with positive shifts in in-plane (10 – 30 cm^{-1}) and out-of-plane (10 – 18 cm^{-1}) pyridine ring vibrations.

(3) In all the deprotonated complexes, the phenolate oxygen(s) and the ozomethine nitrogen(s) take part in bonding as is indicated by the observed negative shift in νC = N, positive shifts in N – N and ν_{sym}. C – O^- modes and appearance of a new band attributed to ν_{asym}. C – O^-. In addition to the above, other bonding sites are involved in some cases depending upon the detailed structure of the ligand.

(4) The band of the coordinated water molecules in 1:1 hydrated complexes disappears in the spectra of bispyridine adducts and new bands are observed at ~1000, ~640 and ~420 cm^{-1} arising from ring-breathing, in-plane and out-of-plane bending modes respectively of coordinated pyridine.

The non-ligand bands observed in the spectra of the complexes in the regions 250 – 470, 320 – 390 and 230 – 340 cm^{-1} are tentatively assigned to ν(M – O), ν(M – N) and ν(M – Cl) modes respectively.

Infrared spectral studies thus indicate uninegative bidentate behaviour of SH and H_2Nolox in their 1:2 deprotonated complexes, uninegative tridentate behaviour of H_2PIS and SEC in their 1:2 deprotonated complexes, dinegative tridentate behaviour of H_2Nolox and H_2Salox in their 1:1 complexes and dinegative tetradentate behaviour of H_2SA in all its complexes and of H_2PIS in Cu(HPIS)Cl.H_2O.

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Electron spin resonance spectral studies

In order to obtain additional evidence for the proposed structures $Cu(HPIS)_2$ and $Cu(PIS).2H_2O$, the paramagnetic resonance spectra of these complexes doped in the diamagnetic host lattices of $Zn(HPIS)_2$ and $Zn(PIS).2H_2O$ were recorded at 77°K. The spectral features are characteristic of axial symmetry. The parallel ^{63}Cu features are clearly resolved while the perpendicular features are broadened, probably owing to the badly resolved ligand hyperfine interactions. The spectral data in each case indicate that the unpaired electron is in the $d_{x^2-y^2}$ orbital of the copper (II) ion. The $g_{\parallel}$ and $g_{\perp}$ values depart considerably from the free-spin value (2.0023) and are close to those reported for distorted octahedral structure of copper (II) complexes. The half-field line at 1560G in the ESR spectrum of $Cu(PIS).2H_2O$ corresponding to a g value of 4.3026 is due to a singlet-triplet transition ($\triangle Ms = 2$) suggesting that the complex involves a dimeric structure.

X-ray powder diffraction studies

The powder X-ray diffraction photograph of $Cu(HPIS)_2$ yieids a blurred ring but no specific diffraction lines, indicating that the complex is amorphous, whereas the powder diffraction photograph of $Cu(PIS).2H_2O$ has prominent lines which, by using the 'trial and error' method (Ito's method) could be satisfactorily indexed for tetragonal symmetry. The lattice parameters computed for the above symmetry are $a = 8.6059\text{Å}$, $C = 17.7\text{Å}$, $\rho = 1.80$ g cm^{-3} and $Z = 4$.

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GEOGRAPHY

LAND-USE OF THE DISTRICT-TOWNS OF THE GANGA-GHAGHRA DOAB EAST : A GEOGRAPHICAL ANALYSIS

Bhanu Pratap Sup : *Dr. A. S. Jauhari*

The Ganga-Ghaghra Doab East (25° 33' N–26° 27' N latitudes and 82° 40' E–84° 39' E longitudes) with a triangular shape is delimited by the two great rivers, viz., the Ghaghra in the north, the Ganga in the south and the administrative district boundaries of Azamgarh and Ghazipur in the West. The Ganga-Ghaghra Doab East includes three district headquarters, viz., Azamgarh, Ghazipur and Ballia with an area of 11,558.9 km² and a population of 56,62,226 persons (1971).

The entire study has been divided into two parts which comprise ten chapters. Chapter I of part I is a geographical background to the region with an emphasis on physical and cultural environments which have a profound influence on the land-use of the district-towns. The geographical background deals with location and extent, physical features, surface configuration, drainage system, climate, soils, vegetation, population, occupational structure, settlements, general land-use, irrigation and transport and communication of the region.

Part II which begins with Chapter II, contains full details of the district-towns. Chapter II, Origin and Evolution, deals with factors responsible for origin and growth, nomenclature, changes of river-courses and site condition of the towns, evolution of the three towns during Hindu, Muslim, British period and the post-Independence period, the existing townscape, spatial shape and the measurement of shape index. Factors of site and situation have been properly analysed in tracing the historical development of the three towns. This chapter provides a comparative study of the origin and growth of these towns with an emphasis on the built-up areas of different periods. Though there has been an ample increase in the built-up area, yet the building activity has not kept pace with the rapid increase of population. The remarkable thing to note is that while the development is taking place in the fringes, the condition of main city has been continuously deteriorating. The Concentric, Sector and Multi-Nuclei theories have been assessed in case of the three towns. The spatial shapes of the

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district-towns have been found out on statistical basis. The urban zones of the three towns have been demarcated on the basis of field work.

Chapter III is devoted to demographic structure of the district-towns. Density and spatial distribution of population in different parts and occupational structure of the three towns have been discussed. Future population of these towns upto 2001 A. D. has been projected. If the population of these towns grows as usual in an unchecked fashion, it is assumed to nearly double within the next three decades. At this overwhelming rate of population growth, these towns are expected to be the victims of overcrowding and appalling congestion. Different population characteristics (Concentration Index, Deconcentration Index, Centralization Index, Ch Index, Cr Inden and Centrographic study) have been analysed on the basis of statistical methods. The population of these towns has grown more by natural increase instead of through migration as there is very little chance for employment in these three towns.

In Chapter IV, an attempt has been made to explain the general land-use characteristics of the district-towns. A comparative study of all types of land-uses has been made to throw light on their land-use characteristics.

Chapter V deals with the residential land-use of the district-towns. The residential areas have been divided into four categories (high class, middle class, low class and slum and ahatas) on the basis of population and housing density, type of buildings, family dwellings and land value. Maximum housing density is found in the Inner Zone, whereas it decreases from the hard core to the periphery. The houses along the principal thoroughfares in the Inner and Middle Zones are used for commercial and residential purposes because of higher land value and lack of open space. Slums and ahatas are found in these congested zones where many persons reside in a single room which is utilized for all purposes. Thus, the district-towns can be improved by providing three facilities : (i) the renewal of the slums, (ii) the planned development of colonies on the outskirts, and (iii) the reconstruction of buildings.

Chapter VI presents the characteristics of business land-use of the district-towns. The varying percentage of land devoted to business activities has been analysed. The Chowks with their various aspects, such as nature, extent, shape, distribution of shops and hourly distri-

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bution of population have been analytically dealt with and statistical procedures have been applied. Overlapping land-use is the most common characteristic of the business areas of the district-towns. Commercial activities are especially being performed in the Inner and Middle Zones, whereas the Outer Zone includes only a few scattered shops either on road crossings or contiguous to public institutions. Intensity and continuity of commercial shops thin out with the increasing distance from the Chowk to periphery.

Chapter VII is devoted to industrial land-use of these three towns. Various types of industries have been discussed on the basis of their nature. Different types of statistical methods have been brought into light for analysing industrial characteristics. These towns are very backward from the point of view of industrial development as there is no heavy industry in any town.

Chapter VIII is especially concerned with land under public uses and vacant spaces. It comprises transportational, government and semi-government offices, parks and playgrounds, recreational, medical and educational land-uses. Public land-uses often bring surrounding remote rural areas in contact with these three towns. The district-towns are far from satisfactory in case of these public facilities except educational and postal services to some extent.

Land-use in the urban fringes has been described in Chapter IX. After analysing a few indices, the urban fringe has been divided into the primary and the secondary fringes. The primary fringe, more or less, coincides with the municipal boundaries excluding the most developed areas of the main towns. The secondary fringe, delimited on the basis of several indices and field work, presents typical rural characteristics as compared to the primary fringe. It will provide adequate open space for future development of the three towns The vacant spaces include water-bodies and useless open spaces. Land under agriculture and market-gardening seem to be open space for a certain period when they are not utilized for associated crops and vegetables.

The last Chapter (Chapter X) is devoted to future land-use planning of the district-towns along with their fringe areas. An attempt has been made to suggest ways and means of eradicating all sorts of problems of use and misuse of land upto 2001 A. D. Comprehensive land-use planning has been anticipated to provide salubrious life to the urban dwellers. The ideal percentage for different types of land-uses has been considered on the basis of previous literature and field work.

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The findings of this work are based on intensive field work and on various types of published and unpublished records and materials. All facts analysed and discussed in the work have been supported by maps, diagrams and tables. A few photographs have been inserted to illustrate some features of the district-towns.

POPULATION GEOGRAPHY OF RAJASTHAN

Rajendra Prasad Sup : *Dr. K. K. Dube*

Rajasthan is the second largest state of India with respect to size, covering 10.4% area and 4.99% population (1981 ; 3.41 crore) of the country. It consists of 26 districts, 196 tahsils, 195 towns (1981) and 33305 villages (1971).

This study entitled "Population Geography of Rajasthan" has been divided into nine chapters. First chapter 'Geographical Setting' deals briefly with the physiography, drainage, climate, resource appraisal including soil, forest, agricultural minerals and transport system of the state.

Second chapter analyses the distribution and density of population. Population is unevenly distributed in the state. The sandy desert of western Rajasthan is thinly populated ($<$50 p/km^2) whereas the eastern, south and north-eastern parts are relatively more densely populated ($>$150 p/km^2). As per 1971 census, 21.2 million population (82.4% of the State's population) is rural, distributed in 33305 villages. Regional variation of population distribution, according to various size of villages, has also been analysed. About 21% people of the state live in 195 urban centres (1981). In Rajasthan, 150 towns became medium sized (classes III and IV) holding 40.8% urban population. More than 46% urban population is concentrated in eleven class I cities ($>$100000 pop.) and 10% in eleven class II (50000-100000 pop.) cities. Urban centres are mainly concentrated in Sekhawati region, eastern plain and southeastern plateau region. Arithmetic density of population often gives an erroneous result, therefore other kinds of densities e. g. physiological, nutritional, agricultural, rural and urban, have been separately compared and analysed.

Population growth of the state, as revealed through Chapter III, has always been higher than the national average. Within eighty years

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(1901-81) period, 231.2% increase has been observed which is much above the overall country's growth (186.84%). After explaining the regional variation of population growth (1961-71). decennial birth and death rates have also been analysed. Infant mortality rate records 63.43 per thousand while maternal death rate 39.33 per ten thousand.

In Chapter IV 'Migration patterns', mobility as a basic component of population growth has been studied in detail. About 30% population has moved from origin to other destinations. About 73.5% of the total migrants of the state are women. Four types of areal migration e. g. rural to rural (70.2% : M-13.1% F-57.1%), rural to urban (14.2% : M-7.2%, F-7.0%), urban to urban (10.0% : M-4.5%, F-5.5%) and urban to rural (5.6% : M-1.7%, F-3.9%) have been measured. Intra-district, inter-district and inter-state movement under the four types of migration have also been marked. About 2.43 lakh people are reported to have come from other countries to Rajasthan. Most of them have come from Pakistan (2 39 lakh) after partition. Age-group, marital status and occupational structure of migrants have also been ascertained.

Chapter V focusses the composition of population, age-sex, marital status, religious and linguistic composition etc. Average sex-ratio of the State (921 female/1000 males) is much below the national average (935) in 1981. Rural sex-ratio (934) has been much higher than the urban (884) in 1981. Age-group and religionwise sex-ratio has also been worked out. After discussing the regional pattern of sex-ratio (1971) it has been found that two age groups (15-34 and 35-59) provide maximum working force constituting 50.1% of the state's population. Hindus constitute a major religious community in the state comprising 89.63% of the total population while Muslims are in minority (6.9%). Other important communities are Jains (1.99%), Sikhs (1.33%) and Christians (0.12%) etc. There are 36 spoken languages with 54 local dialects. About 91% of population is mainly Hindi speaking.

Chapter VI analyses the literacy condition of the state. Only 24% (1981) people of the state are 'literates' which is much below the national figure (36.17%). There is wide difference between male (35.78%)—female (11.32%) and rural (13.85%)—urban (43.47%) literacy. Level of education, literacy by age-groups and occupational groups have been explained. Urbanisation, industrial and commercial development, irrigation and transport facilities have also affected the literacy rate. Regional variation of literacy shows high literacy in

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plains and south-eastern plateau region whereas low literacy in the western sandy plain and forested hilly region.

Occupational structure of the state, discussed in Chapter VII, reveals that about 31.2% of the state's population comprises of workers (1971), which is slightly below the national average (32,9%). Marked difference is obvious in the working force between male (52.1%) female (8.3%) and rural (32.4%)—urban (25.8%) population. Rural workers engaged in primary, secondary and tertiary activities are 87.9, 4.0 and 8.1% respectively whereas the ratio of urban workers in the above activities comes to 14.3, 22.6 and 63.1% per cent respectively. About 25.6% workers of the state are engaged in non-agricultural pursuits. Their regional variation has been discussed in detail.

Chapter VIII is devoted to the analysis of population attributes of scheduled castes (40.76 lakh) and scheduled tribe (31 lakh). About 85% of scheduled castes and 98% of the tribes live in rural areas. Eight major scheduled castes account for 80% of total scheduled caste population. They are 'Chamar' or 'Bhambhi' or 'Jatav' (38.65%), 'Megh' or 'Meghwal' (14.76%), 'Balai' (8.3%), 'Thori' or 'Nayak' (5.4%), 'Koli' or 'Kori' (3.94%), 'Khatik' (3.74%), 'Bairwa' or 'Berwa' (3.46%) and 'Bhangi' (3.25%). Majority of the scheduled castes (>21%) live in agricultural tracts of the state including northern canal irrigated area, north-eastern plain and some parts of south-eastern plateau region. Their population growth, literacy, age-sex composition, marital status and occupational structure have been discussed in full detail.

There are 13 tribal communities (1971), out of which six are quite significant. 'Bhil' and 'Mina' are most important tribes which contribute 94 per cent of the state's tribal population. Majority of scheduled tribes occupy hilly and forested areas of south. Tribal's population growth, age structure, sex-ratio, marital status and literacy have been separately studied in detail. Problem of unemployment is more acute among tribals due to their low social consciousness. About 95.6% of tribal workers are engaged in primary activities, 1% in secondary and 3.4% in tertiary activities.

Chapter IX concludes with the delimitation of population regions and their planning. With the help of seven variables : (a) Physiological density, (b) Urbanisation, (c) Road density, (d) Literacy, (e) Female literacy, (f) Net-irrigated area and (g) ratio of non-agricultural workers—four population regions (Dynamic, Transitional, Prospective and

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Problem) have been identified. Seven population potential regions have also been ascertained on the basis of the population potential values of eleven class I cities (1981) of the state. Generalisations at regional level have been tested and proved through sample studies (12 villages and 6 towns), selected through purposive random sampling method from different physiographic/population regions of the state. There are various problems—physical (rugged relief, aridity etc.), socio-economic (scarcity of natural food resources, poor industrial development, low per capita income, poor transport, poor literacy, poor medical facilities etc.), demographic (high growth rate, migration), and related to tribals (high populaiion growth, poor literacy, socio-economic backwardness, etc.) as well as border areas. Planning proposals given in the end are based on projected population (5,97,44,147 for 2001 A. D.) as well as future needs of the people with regard to various resources and essential facilities.

AGRICULTURE IN MIRZAPUR DISTRICT, UTTAR PRADESH : A GEOGRAPHICAL ANALYSIS OF DEVELOPMENT, PROBLEMS AND PROSPECTS

Kamala Prasad Sup. : *Dr. R. N. Mathur*

Chapter I is devoted to the 'Physical Background' of the area. Mirzapur district (23° 52′ N: 25° 32′ N; 82° 7′E: 83° 33′E), characterized mostly by difficult terrain and frequent flood and drought hazards, represents a geological complex exemplified by rock exposures of almost all of the main geological periods, right from the Pre-Cambrian to the Recent. Five major rock combinations can be identified (Archaeans, Bijawars, Vindhyans, Gondwanas and the unconsolidated alluvial deposits of Plaistocene to Recent). Physiographically, the northern most 16.03% part of the area is a plain tract whereas the rest is an upland tract. The former is a part of the Middle Ganga Plain and the latter of the Vindhyan-Baghelkhand region. Amongst the 7 types of soils identified in the area, the clayey and the sandy loans are the most significant from the agricultural point of view.

Chapter II, on 'Cultural Setting', deals with population, occupational structure, settlements, transports and communication, medical facilities, education, electrification, agricultural finance and marketing, industries and irrigation. The District exhibits marked spatial variations in the distribution of rural (88%) and urban (12%) population with an

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average density of 241 persons/km² (1975). The decennial growth rate of population comes to 23.42% (1961-71). A predominantly large proportion of working population is engaged in agriculture (97.74%). There is a well marked spatial variation in the distribution of rural settlements (average : 0.28 hamlet/km²). In general, three settlement patterns, compact, semi-compact and sprinkled are observed in the study area, Large agglomerations can be seen in the Plain and in the Belan Valley whereas smaller settlements predominate in the highly dissected parts of the Sonpur upland.

Roads and railways form the important means of transportation. About 90% of the total villages of the District are situated at a distance of above 5 km from a metalled road. The post and telegraphic services are very unevenly distributed over the District. About 98% of the total villages of the District are situated at a distance of above 5 km from a post-office. More or less similar conditions prevail in the case of medical facilities, for example, on an average, there is one primary health centre per 7,710 persons.

As regards educational facility, it is mostly confined to the northern part. The poor state of educational facility is indeed a major factor in the extremely slow progress towards modernization of agriculture, especially in the southern part. There are two hydro-electric stations in the District, viz. Pipri and Obra. The highest rural electrification is recorded by the Majhwa and Sikhar blocks with above 70% of the villages in each case being served by electricity. In fact, only 14% of the total villages of the District lying mostly in the Plain area have been electrified so far.

Different institutions provide financial and other aids for agricultural development but the facilities do not generally benefit the farmers equally, specially the smaller farmers. Mirzapur, Chunar, Robertsganj, Pipri, Churk, Dala, Renukoot, Dudhi, Ahraura and Obra are the main industrial nodes, alongwith smaller centres like Narainpur, Kailhat, Murdhwa, Muirpur, Bhuili, Serwan etc.

The important means of irrigation are canals, wells, tube-wells and ponds, accounting respectively for 47.5, 29.1, 14.3 and 9.1% of the total irrigated area. A significant feature of irrigation is that tube-well irrigation is almost confined to the Plain tract whereas pond irrigation to the upland tract.

The landuse, intensity of cropping and agricultural practices have been discussed in Chapter III. The areas under forest, uncultivable

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land, cultivable land and cultivated land are respectively 39.31%, 8.71%, 15.16% and 36.82% of the total area of the District. The forested area has recorded a decline of 30.29% (1955 to 1975) while the uncultivable land has increased by 29% due to increasing development of infrastructural facilities and the institutional framework. The area under uncultivable land has also registered a decline of 35%.

The average cultivated area per cultivator comes to 1.95 ha for the District as a whole. As regards the technological developments, the different technological innovations have more rapidly been adopted by the bigger farmers, almost wholly confined to the Plain tract, as compared to the smaller farmers.

The average utilization of nitrogen, phosphorous and potash in the District comes respectively to 19.15, 6.47 and 2;77 kg/ha of cultivated area. The high yielding variety of seeds (HYVS) are being used only for wheat, paddy and maize since these are the more important crops on account of their high returns. The use of plant protection measures is almost wholly limited to the bigger farmers. Most of the farmers are still using the traditional implements. However, the use of tractors has gained significance in the northern part whereas draught animals predominate in the southern part.

Chapter IV deals with cropping pattern, regional imbalances in food crop production, crop diversification, cereal availability and crop combination regions. The Kharif crops dominate in the southern part of the District while the Rabi crops in the northern part. An attempt has been made to find out the regional imbalances in food crop production through the measurement of agricultural productivity by using three indices : (i) standardized crop-yield index; (ii) weighted crop equivalent index ; and (iii) cropping intensity index. The index of productivity per unit net area sown has been found to be the highest (above 100) in the Majhwa, City, Jamalpur, Narainpur and Robertsganj blocks, all situated in the plain tract with the exception of the last block.

The surplus or deficit grain production has also been determined by finding out cereal availability index on the basis of a personal field survey of 14 sample villages. Most of the blocks of the northern part, alongwith Dudhi, have paddy as the first ranking crop, followed by wheat or small millets at the second place.

Chapter V deals with the 'Livestock Resources' of the District. Animal husbandry is mostly practised on a mixed farming basis, except for some castes like 'ahirs'. Out of the total livestock units, the percentage under different categories are : bovine-81.38%, ovine-7.65%,

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equestrian-5.23%, poultry-1.28% and others-4.46%. The quality of livestock is far better in the northern part as compared to the southern on account of a higher level of economic development in the former.

In Chapter VI, on 'Agricultural regions, problems, prospects and planning', an attempt has been made to stress the agricultural problems and prospects of different agricultural regions (prospective, transitional and depressed) demarcated on the basis of selected significant variable. Six blocks, that is, Majhwa, Sikhar, Narainpur, Jamalpur, City and Robertsganj fall under the category of prospective region due to the most favourable agro-economic conditions in the whole of the District. Eight blocks. that is Chhionway, Kon, Pahari, Lalganj, Marihan, Rajgarh, Chatra and Ghorawal fall under the category of a transitional region. Six blocks, that is Hallia, Nagwa, Chopan, Muirpur. Dudhi and Babhani fall in the category of a depressed region.

A perspective plan has been presented for the best possible agricultural development of the District by the year 2001 A, D. An estimation of area under the main crops and their requirements of HYV seeds has been made according to the norms prescribed by the U. P. Government Agriculture Department. Likewise, fertilizer requirements for the same period have been estimated on the basis of nutrients consumed by plants. Suggestions have been put forward for the agricultural development of the area. The farmers need be made conscious of the proper use of irrigation water, both with respect to its amount and time of application. Facilities for credit, finance and proper marketing should also be strengthened or developed. The prospects for the development of animal husbandry and poultry have been put forward for improving the socio-economic conditions of the people, especially the landless agricultural labourers.

The present study thus, attempts to present a clear picture of the development, problems and prospects of agriculture in the Mirzapur district and to suggest a suitable plan for the optimum agricultural development of the area.

SERVICE CENTRES PLANNING OF JAUNPUR DISTRICT

Mata Prasad Singh Sup. : *Dr. H. H. Singh*

The study area, Jaunpur district, forms the north-western portion of the present division of Varanasi. It extends from 25° 26'N to 26° 11'N latitude and 82° 08'E to 83° 5'E longitude with an area of 3999.83 km².

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The district comprises five tahsils viz. Jaunpur, Shahganj, Machhlishahar, Mariahu and Kerakat and its total population is 25,27,492 (1981).

The district is a level plain and drained by the Varuna in the south-west, the Gomati in the south-east, the Gangi in the north-east and the Manghai in the north. On the basis of various physiographic characteristics, the area can be divided into three physical divisions, namely (i) northern tract, (ii) central tract, and (iii) southern tract. The district enjoys tropical monsoon type of climate. About 73% of land is under cultivation, varying from 57.2% in Mungra Badshahpur to 80.43% in Kerakat. Wheat is the leading crop almost throughout the district except a few development blocks. Wheat, rice and maize are the leading crops covering 24.97%, 22.15% and 11.56% respectively of the total net sown area of the district (1978-79). During 1978-79 about 57.36% of total cultivated land was irrigated.

The decade 1921-31 marked an overall growth rate of 7% which rose to 16.10 in 1961-71. According to an estimate the population of the district will be 31,38,100 persons by A. D. 2001. The district records an average population density of 496 persons/km^2, but variation at block level are noteworthy ranging from 292 (Mungra Badshahpur) to 570 (Jalalpur). The proportion of literates (21.20%) is lower than the state average (21.70%). The female population is less literate (8.10%) as compared to male (34.50%). Out of the total working population, only 25.72% of the total population are agricultural workers. On the basis of different population characteristics the whole district is divided into three regions : the dynamic, the prospective and the problem region.

In the present study, settlements with the following facilities have been treated as service centres, (i) the settlement must be of permanent nature, (ii) population – 1000 or more, (iii) out of its total population people engaged in secondary and tertiary activities must be 4% or more, (iv) out of the total regional commercial population the share of the centre should be not less than 0.05%, (v) the marketing facilities is a must, (vi) there must be road connection, (vii) out of the following amenities, e. g., education, medical, administrative and post and telegraph, at least two should be there. On the basis of the above seven criterian there are 74 service centres which form the theme of thesis. To analyse the distributional characteristics of the service centres three spatial attributes are taken into consideration, e. g., spacing of service centres observed (rO) and hypothetical (Hs), index

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of randomness (Rn) and index of disturbance (Di). Hypothetical spacing at block level, ranges from 5.79 km (Shahganj) to 11.53 km (Khuthan), which are grouped into four categories, i. e., very low, low, moderate and high spacing. The radial distribution of function of service centres is interpreted by plotting the spacing and density of the centre. It is found that the spacing increases when density decreases and *vice-versa*.

Historical records reveal that in the ancient period most part of the area was clad with wood lands. At the time of Akbar (1556-1605) there developed three-tier territorial organization, e. g., *Pargana, tappa* and *gaon*. The district, has many such centres and towns where industries were developed, particularly at Jaunpur, Mungra Badshahpur, Kerakat and Mariahu. Pre-independence period has contributed much more to the development and extension of centres, than any other single century. The origin and improvement of motor bus traffic have brought changes in the nature and influence of a large number of service centres. Several government departments have launched their services to the villages and service centres. The facilities in respect of the integrated area development scheme, directly or indirectly, have influenced the growth of service centres.

On the basis of certain criteria the centrality of a centre has been calculated and identified as 'Composite Index'. The average of the three values (Fi, Ci, Wi) have been finally taken for ranking of service jointly together expressed in the form of the composite index. Hierarchy of service centres has been calculated by composite index. The range of such indices varies from 36.22 (Jaunpur) to 6.75 (Garion). Thus four tier hierarchy of service centres has been evolved. Considering 'Cmi' as the base, four-tier scheme of hierarchy has been prepared having a frequency of 5, 8, 23 and 38 in descending order.

Complementary regions of service centres have been represented by 'Reilly's Law' of Retail Gravitation, adopted with slight modification. Further complementary regions are delineated in reference to choice and space preference. Service area for fourth order centres is 8.18 million population, with 1819.78 km^2 and 1322 villages. Service area for third order centres is 5.73 million population, 1084.33 km^2 and 1142 villages; for second order it is 3.01 million population, 706 79 km^2 area and 515 villages, and for the first order it is 3.12 million population, 429.10 km^2 area and 420 villages. Various aspects influence the morphology of service centres-origin and evolution, physical and cultural setting, population growth, road-net, etc. Shahganj and Kerakat are

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the first order service centres ; they have administrative (tahsil, block and police station), commercial (large number of business establishments), residential, education and transportational facilities (road and rail). Badlapur, Chandwak and Leduka are second order centres. Such type of service centres are in transitional stage between village and town and may be termed as urban centres. These centres are growing fastly and it is expected that in future they will have faster growth. Sujanganj is a third order service centre with limited number of functions.

Considering the spatial infilling (areal gaps, population gaps and functional gaps) and future population growth, the spatial plan has been suggested. It has been predicted that at the end of this century (A. D. 2001) the region will have 118 service centres in different hierarchical order (8, 15, 30 and 65). The proposed organization of service centres in spatial context represent an ideal system for planning with a view to minimizing regional imbalances through service centres. Thus, they will serve the region better by physical and cultural amenities. In the proposed system the dispersion would be higher than the existing situation as represented with Rn and Di values : in 1971 these values were 1.05 and 48.92 while in A. D. 2001 it is expected to be 1.36 and 63.46, respectively. Numerical growth is further responsible for reducing the hypothetical spacing (Hs) of service centres which is 8.64 km but with the proposed system it will be 7.15 km in A. D. 2001. With such change, the areal density and hypothetical spacing (Hs) will be minimized, but the service range in population would be increased; on an average a centre serves 26,594 persons, while in areal context, the range will be more capable to serve the surrounding territory. Jaunpur is considered as a nodal centre in terms of administrative functional organization and control.

With the aim of comprehensive development, a scheme in integrated frame, especially taking agriculture, industry, education, medical and transportation facilities on the top, has been suggested for future development. Integrated rural area development as referred in term of multi sectors, e. g , agriculture, industries, education, health and transportation; multi-sections, dealing with socio-economic development of various poor sections, e. g., landless, labourers, artisans, small farmers, marginal farmers, scheduled caste and scheduled tribe and multi-level considering rural development in various levels of settlement hierarchy like, village, cluster village, blocks and district, especially considering different aspects and different context, be synthesized and a comprehensive plan is to be developed.

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RESOURCE UTILIZATION AND PLANNING IN WEST U. P. TARAI : A CASE STUDY OF BAZPUR, RUDRAPUR AND KHATIMA BLOCKS OF DISTRICT NAINITAL

Km. Veenum Verma Sup : *Dr. R. L. Singh*

The study region is a part of west U. P. Tarai which comes in the southern portion of Nainital district and lies between 28° 43'N-29° 16' N and 79° E-80° 5' E. The study region comprises Bazpur, Rudrapur and Khatima blocks with 21 adalat panchayats.

The histogenesis of the region indicates that most of the area must have been completely under forest in ancient period but some patches of settlement have been found, as the ruins of Govisana fort indicate. In medieval period too there were few settlements in the area. This is observed that the growth of settlement suffered tremendous set back due to extremely adverse climatic conditions and wild animals of tarai. In the British period too several attempts were made to inhabit this area but the epidemics of 1886 A. D. and 1914 A D. greatly reduced the population again. After independence the land reclamation and colonization schemes of Govt. of U. P. were started in 1948 to resettle the area. The massive efforts made by the government is proving a success and the hard work and continuous efforts by new settlers like Punjabis and political sufferers have developed this area, agriculturally.

The important natural resources of the region constitute land, water and forest. The potential value of these resources is very high in respect of agricultural productivity and forest-based industries.

It is to be noted that the area covered by the forest is reduced after implemention of colonization and reclamation schemes.

U. P. government now has started plantation of Eucalyptus and poplar trees which has increased the revenue from Rs. 550/hectare in 1960 to Rs. 6000/hectare in 1967. The pace of plantation is increasing fast especially in Bazpur and Rudrapur blocks. In Khatima block too plantation is essential. The utilization pattern of forest resource is not yet developed.

In the region water uses are confined primarily to agriculture and domestic uses. The region receives a high annual rainfall (about 2000 mm) of which more than 75% is received in rainy season. The irrigated land in Bagwada, Narainpur, and in Barakhera adalat panchayats is more than 60% and in Khatima, Bandia, Anandkhera and Chakarpur

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adalat panchayats the irrigated land is between 50 and 60% and in the remaining adalat panchayats the irrigated land is less than 50%. The ground water is available at a very convenient depth, therefore, many farmers have installed tubewells in their farms. Artesian well are also becoming common in this region. Before 1971 canals were main source of irrigation but now tubewells have become significant for irrigation. The upper strata water of the area is commonly used for drinking and domestic purpose which is unhygienic due to the presence of iron and lime etc. Water borne diseases are common in this area. For supply of hygienic drinking water, ten rural water supply schemes and 'Kumaon Jal Sansthan' are in action. But the water supplied is not sufficient for the entire population.

The average population density of the region in 1971 was 216 persons per Km^2 which increased to 246 persons per Km^2 in 1981. The growth rate is increasing rapidly due to improvement in medical facilities etc. Major concentration of population is found in Rudrapur, Tanakpur, Kichha, Sitarganj, Khatima, Bazpur and Gadarpur. In Barhani, Kelakhera, Govindpur, Bandia, Darau, Narainpur and Aambag adalat panchayats, population density is high, above 240 person/Km^2.

Buxas and Tharus are the two aboriginal tribes of the region. The Buxas are inhabited in the western part of the region in Bazpur block and the Tharus are inhabited in the eastern part or in Khatima block. Out of 225 villages of Khatima block 85 villages are inhabited mostly by Tharus.

58.47% of total working population of Rudrapur block, 82.85% of Bazpur block and 81.46% working population of Khatima block are engaged in forestry, transport and communication and small scale industries etc.

The literacy in rural areas on adalat panchayat level is 26.04%, whereas in urban areas it is more than 39%. The recent trend in education has been definitely upward with the establishment of many educational institutions and G. B. Pant Agriculture and Technology University. There is also an educational institution in Khatima, especially, for Tharus where they are given free education with hostel facilities.

The pattern of land utilisation has undergone remarkable changes after implementation of the colonization scheme. More than 70% of total geographical area is under cultivation in almost all the adalat panchayats except Sisauna, Kelakhera and Aambag adalat panchayats etc.

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The fertile soil and agro-climatic conditions of the region permit a wide range of crops to grow successfully. At present the region is one of the most agriculturally developed regions of U. P. Paddy, maize sugarcane are the main Kharif crops and wheat, gram, oilseeds, masoor etc. are the Rabi crops. Double cropping pattern is prominent in the region due to the cheap labour and skill of Punjabi farmers, and better seeds, good manuring and due to facilities rendered by Tarai Development Corporarion and G. B. Pant Agriculture and Technology University, and multipurpose cooperatives and credit societies. The Punjabi villages are more developed than non-Punjabi villages. In comparison to other farmers, Buxas and Tharus are progressing slow in agriculture. Mostly the large and medium scale farmers have adopted the modernised practices but small holding farmers are far behind in this respect. Irrigation facilities have increased from 41.26% to 71.75% in Bagwada, Darau, Narainpur, Anandkhera, Govindpur adalat panchayats within two decades.

Horticulture has also been encouraged by Pattharchatta Horticuiture Centre which has brought out a turning point in the field of production of fruits, vegetables and spices etc., which can give extra income.

The region has also ample scope to develop livestock resources as a subsidiary industry in the rural areas. Nagla dairy farm has revealed the potentialities of the region to support modern dairy industry, poultry and fisheries for the development of rural area.

The land put to non-agricultural purposes are forest, settlement, cultivable waste and uncultivable waste etc.

The spatial-pattern of transport system requires further extension and development for proper growth of the region. There is a need to link the long-distance villages which will result in proper resource utilization and acceleration of economic activities. To assess the dormant capacity of the region in supporting its population, the study attempts to regionalize the study area into population/Resource Regions which are the result of interaction of population resources on the one hand and natural resources on the other. For this purpose five variables have been taken into account, i. e. (i) Rural population density, (ii) Rural population growth rate, (iii) level of urbanization, (iv) literacy, (v) non-agricultural workers. Level of economic develepment has been identified by deviation-indices. Out of 21 adalat panchayats, one adalat-panchayat, Bagwada, shows the characteristics of dynamic region. 14 adalat panchayats are identified as prospective and 6 as

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problem regions. Bagwada is relatively more urbanized, industrialized, having better transport facilities, high percentage of non-agricultural workers and high literacy due to the influence of Rudrapur and Pantnagar. Prospective area is consisted of Anandkhera, Barakhera, Govindpur, Bara, Bandia, Narainpur, Khatima, Bigrabag, Kalyan-nagar, Bandia (Khatima block) and Nanakmata adalat panchayats. The area is rich in land and water resources. Agriculturally the area is developed but the low level of urbanization, lack of industrialization and low literacy are the limiting factors in the proper growth and development of the area. Chakarpur, Barhani, Kelakhera, Darau, Sisauna, Jhankat and Biria adalat panchayats indicate the characteristics of the problem region, having high growth rate, low literacy and very low percentage of non-agricultural workers. There is a high concentration of Bengalis, Muslims and tribals in this area. The traditional backward agricultural method and high population growth rate etc. are responsible factors for the stagnant economy of the area. Now several efforts are being made for the progress of the tribal population by state government.

In the existing level of economic development of the region, although, the agriculture is developing fast, yet yield produced by small farmers especially in Bengali and Muslim villages is low and the agriculture on tribal land is still backward.

It is to be noted that there is lack of industries in the region, e. g., forest products available in the region are sent outside for manufacturing paper, pulp etc. Agro-based industries are also less in number. The development of agro-based and forest-based industries would further strengthen the economic growth of the area. The other problems are insufficient transport network, problem of drinking water, the development of tribals and development of social education, and economici nstitutions.

An integrated rural area development plan for A D. 2001 has been proposed for Rudrapur block as a sample study. It is estimated that in 2001 A. D the population will be one and half times more than the present population. Keeping in view the existing level of economic development and growth rate in all the 5 adalat panchayats, physical infrastructure (rural roads, rural water supply, rural markets etc.) and social infrastructure (rural health, rural education etc.) are integrated with production supportive components (irrigation, farm mechanization, grain storage and processing and rural credit etc.). The service centres are also proposed for development of the region. The landuse pattern

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indicates that only 56% land is under cultivation in Bandia adalat panchayat. For agricultural reforms and land development high yielding variety seeds and more irrigational facilities are suggested for Bara and Bandia adalat-panchayats. It is suggested to develop dairy and poultry in the villages of Muslims, Bengalis and in the villages of landless agricultural labourers. Only 43 villages are connected by roads which indicate that less than half of the area only, is linked with roads. Here it is proposed to link the villages which are settled on a distance of more than 5 Kms from the metalled road. It is also proposed to convert some important unmetalled roads in metalled roads. Educational institutions and primary health centres are proposed. To meet the requirement of drinking water supply for rural population it is suggested to increase the capacity and efficiency of the rural water supply schemes.

The heavy and small scale industries are also proposed for balanced economic development of the region.

For proper channelization of resources and proper arrangement of energy flow and movement the spatial-organization of service centres are proposed for A. D. 2001. The same integrated area development plan is proposed for the whole region for implementation. Further a micro-level plan for village Majra-Hassan is proposed which is inhabited by the Buxa tribes, for integrated development.

WATER RESOURCES OF THE BASTI DISTRICT, UTTAR PRADESH : A GEOGRAPHICAL STUDY

Abhaya Kumar Jain Sup. : *Dr. R. N. Mathur*

The present work is devoted to a study of the development of water resources in the Basti district during the period 1960-61 to 1976-77. The former year marks the end of the 2nd and the latter marks the end of the 5th Five Year National Plan. In fact, systematic development of water resources of the study area was for the first time taken up in the Second Five Year Plan and thereafter it continued in the successive plans so that most of the water resources developments, envisaged during these plans, had been attained by the year 1976-77.

The study area, a part of the Middle Ganga Plain, is well suited, both from physical and cultural points of view, for the development of water resources, both surface and subsurface. These developments

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have obviously been necessitated on account of the ever-increasing demands for water, especially in agriculture, in this predominantly agricultural area. In fact, more than 80% of the area is under agriculture and the subsistence food crops occupy about 90% of the gross area sown. Paddy, the most dominant crop, occupies 88% of the kharif cropped area, followed by wheat with 68% of the rabi cropped area. The industrial development of the area is almost wholly confined to the agro-based industries like sugar, khandsari, oil crushing, flour-milling, wine, leather etc. The quality of both surface and ground water has been found to be suitable for different uses.

Rivers, ponds and reservoirs are the main source of surface water supply, tapped through a network of canals, for example, the Banganga, the Basti, the Kuwano, the Bhakhira, and the Jamindari canals. Ground water in the study area is not confined under pressure, but occurs under water table conditions, at least upto the depth of about 90 m ordinarily reached by tubewells. The water table depth below ground ranges from 3 to 5 m.

The total available water resources in the study area in 1976-77 amounted to 4,332,450 ha m, the proportion of surface and subsurface water being 8% and 92% respectively. The total water requirements in the area in 1976-77 have been estimated at 171,158 ha m, the break-up being : agriculture – 91.2%, domestic and municipal—8.1% and industrial – 0.7%.

The total water utilization in 1976-77 amounted to 85,341 ha m, of which surface water accounted for only 8.5%. Out of the total utilized water, as much as much as 93.8% was utilized in agriculture, followed by domestic and municipal – 5.4% and industry 0.8%.

The area is served by different means of irrigation, that is, tube-wells, pumping sets, masonry wells and canals, in decreasing order of importance. Irrigated area under each of the first three exhibits marked spatial and temporal variations in the north-eastern part. The intensity of irrigation has registered an increase of 15.5%, from 43.7% in 1960-61 to 58.2% in 1976-77. On the other hand, the volume of water used in irrigation has registered an increase of 47.4% from 52,924 to 78,013 ha m.

The crop water requirements in 1976-77 have been estimated at 601,465 ha m. These have registered an increase of 7.41% during the period under consideration on account of an increase in the gross area sown, that is, by 5 8% during the same period. Rain water meets 85% of the crop water requirements in the kharif season and 35% in the rabi

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season. Hence, irrigation water required in a crop year is taken as 15% of the kharif and 65% of the rabi crop water requirements respectively. So that, in 1976-77, total irrigation requirements were estimated at 152,391 ha m.

The livestock water requirements were estimated at 3,762 ha m, of which only 54% had been met with in 1976-77. The livestock water consumption in different parts of the District is almost uniformly similar.

The domestic and municipal requirements in 1976-77 were estimated at 13,884 ha m, of which 33% had been met with from the available sources. The industrial requirements were estimated at 1,121 ha m, of which 60% had been fulfilled. Pisci-culture, a non-consumptive use of water, is also commonly practised in the District.

Irrigation water losses, floods and droughts, salinity and alkalinity, and waterlogging are the main problems related to or arising out of water use in the study area. The food frequency comes to 6,4 and 1 per decade for low, medium and high intensity floods respectively. There is urgent need for adoption of conservation practices in the study area, especially to check irrigation water losses. The methods suggested for the purpose are : border-strip irrigation, check-basin irrigation, furrow irrigation and sprinkler irrigation.

Water resources planning takes into account the physical, cultural, social, economic and technological factors related to water supply and use in the area. The water requirements by 2001 A. D. have been estimated at 214,300 ha m on the basis of average rate of increase in population, agriculture, industries etc. The break-up of requirements is : agriculture—175,854 ha m, domestic and municipal—34,734 ha m, and industrial 3,712 ha m. The water requirements of the District in 2001 A. D. would be easily met from the available water resources. However, on account of the progressive socio-economic development of the study area under the different Five Year Plans, the water consumtion in 2001 A. D. would be 144,126 ha m, that is 67% of the total requirement.

A conjunctive development of both surface and ground water resources would be an ideal approach to water resources management. However, on account of the obvious limitations in the future development of surface water resources in the area, it has become imperative to lay stress on the development of the so far unutilized ground water potential. The additional number of wells required for the purpose, in 2001 A. D. have been worked out as : STW 481 ; PTW 15,709 ;

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PS 17,814 ; and MW 23,805, keeping in view the present trends and the future requirements.

An interaction model of the water resources plan is based on the socio-economic conditions and available potential of the water resources in the study area. There are three main inter-dependent water consumer sectors, that is, agriculture, population and industry. For instance, agriculture depends upon population and industry for supply of labour and implements respectively. Similarly, population depends upon agriculture and industry ; and industry depends upon agriculture and population. Therefore, a systematic water resources development plan, which takes into account all these sectors, should be implemented in the study area for its integrated development.

HYDROLOGY AND WATER RESOURCES OF CHANDAULI AND CHAKIA TAHSILS, VARANASI DISTRICT, UTTAR PRADESH : A GEOGRAPHICAL STUDY

Kailash Singh Yadav Sup. : *Dr. R. N. Mathur*

The present study takes into account the influence of physical as well as the cultural factors on the hydrology and water resources of the area. The study, with emphasis on water as a resource, is essentially interdisciplinary in approach. The study covers the period 1971-72 to 1980-81, almost wholly coinciding with the rapid development of water resources in the area. A detailed appraisal of the water resources of the area has not, however, been carried out so far.

The study area (24°4'N-25°32'N ; 83°0' E-83°24'E), comprising of two conterminous tahsils of Varanasi district, that is, Chandauli and Chakia tahsils, covers an area of 2,530.80 km². It forms a transitional zone between the Peninsular uplands in the south and the Ganga Plain in the north—the former represented by a part of the 'Mirzapur Plateau' and the latter by a part of the Chakia-Chunar Plain. The study area thus provides a fair representation of different physical conditions met with in the region and is of great agricultural significance on account of its favourable climatic, soil, and terrain conditions and a large-scale development of irrigational facilities.

Chapter 1 deals with the hydrological cycle, the area, population, landuse, previous investigations, and nature of present study, methodology and approach of the present study. The economy of

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the area is under-developed and is overwhelmingly dominated by agriculture which is mainly subsistence arable farming. The general landuse pattern is clearly influenced by suitability or otherwise of the terrain for agriculture.

Chapter 2 is devoted to the physical aspect related to hydrological conditions, including relief and drainage, climate, geology, hydrological properties of water bearing materials, soil and vegetation. The geohydrological conditions have been studied with the help of the tube-well strata chart. The unconsolidated alluvial deposits of Pleistocene to recent age cover the Plain whereas the pre-Cambrian rocks of the Upper Vindhyan system cover the Plateau.

Chapter 3 deals with the hydrological characteristics of the area like rainfall, run-off, infiltration, evaporation and transpiration, water balance, depth, form and fluctuations of water table, and ground water recharge and discharge. The monsoonal rainfall regime is very clearly reflected in the run-off pattern of the inflow hydrographs of the reservoirs in the area. The outflow hydrographs are, obviously, largely influenced by irrigation water demands. A comparison of climatological water balance conditions between the Plain and the Plateau tracts exhibits significant differences, and both are characterised by well marked water deficit period.

The average wet and dry seasonal water table depths below the ground for all of the observation wells come to 4.08 and 7.81 m in the Plain and 3.59 and 6.72 m in the Plateau tracts, with a northerly gradient of 1:1,750 and 1:198 respectively. Ground water recharge in the area occurs from rainfall, canals and irrigated fields whereas discharge occurs mainly by pumping from wells.

Chapter 4 is devoted to a study of the sources of water and their distribution, and assessment. The surface water is tapped mostly from streams by the construction of reservoirs in the Plateau tract and by pump canals in the Plain tract whereas ground water is tapped by state tube-wells (STW), private tube-wells (PTW), pumping sets (PS), masonry wells fitted with persian wheel (MWP) and masonry wells (MW) all of them largely concentrated in the Plain tract. The traditional ground water lifting devices are fast giving place to the modern power-driven mechanical devices. The utilizable potential in the study area has been estimated at about 200,985 ha m of which 51,889 ha m is from surface and the rest from ground water sources, apart from the ground water available from storage (332,898 ha m).

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Chapter 5 deals with the water quality, use and requirement, and associated problems related to or arising out of water use. The water quality both of surface and ground water, with respect to physical, chemical and bacteriological characteristics, has been found suitable for the different uses in the area. Canal (both gravity and pump canal) is the most significant means of irrigation, accounting for 84.41% of the net area irrigated in 1980-81. The breakup for the rest is : STW-2.89%, PTW-5.29%, PS and MW-7.08% and others (MWP, Ponds and Bundhies etc.)—0.40%. Paddy occupies the most important place amongst all the crops with 54.97% of gross area irrigated, followed by wheat : 33.02% and sugarcane : 4.00%, and the rest distributed amonst the other crops.

The total water consumed in the area in 1980-81 comes to 51,568 ha m of which about 72% is from surface water and the rest from the ground water sources. In the period 1971-72 to 1980-81, utilization of surface water and ground water in irrigation has registered an increase of 38.74% and 62.55% respectively. Out of the total water consumed in 1980-81, as much as 94.35% is used in irrigation, followed by livestock : 1.16%, domestic and municipal : 2.59% and industrial : 1.90%. The corresponding percentage of water requirements, with a total estimated value of 53,169 ha m, are 92.96%, 1.41%, 3.63% and 2.00%. Irrigation water losses, floods and waterlogging, droughts and water scarcity, and soil salinity are rhe main problems related to or arising out of water use in the area, and possible solutions for the same have been suggested.

Chapter 6 deals with conservation and planning of water resources in the area under study. Areas of under—, over—, and balanced-utilization have been delineated. A conjunctive use of the surface and ground water resources has been emphasized as an ideal approach to water resource management with due regard to the possible ecological imbalances resulting from man's influence on the hydrological cycle. The different conservation practises suited to the area, in context of problems met have been suggested. The projected total water requirements by 2001 A. D. are estimated at 82,508 ha m, the break-up being : irrigation-86.70%, livestock-1.53, domestic and municipal-9.32% and industrial-2.63%, based on average rate of increase in population and in the different sectors of the economy. These requirements would easily be fulfilled from the available water potential. The total water expected to be consumed in 2001 A. D. has been estimated at 80,060 ha m, that is, 97.03 % of the total requirements.

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The addltional number of wells required by 2001 A. D. have been estimated as : STW-285, PTW-3,050, PS-3,565 and MW-5,234, keeping in view the present trends and the future developments. However, with the almost full utilization of surface water potential, it has become imperative to tap the unutilized ground water potential for meeting the ever-increasing water demands. Therefore, a water resources development plan which takes into account all these aspects should be implemented in the study area so as to bring about its integrated developments.

AGRICULTURAL TYPOLOGY OF VINDHYANCHAL-BAGHELKHAND REGION, MADHYA PRADESH, INDIA

Munnu Lal Sup. : *Dr. V. R. Singh*

Agricultural typology is the most recent methodological tool in the field of economic geography to illustrate the overall picture of an agrarian landscape. The objective of the present study is to adopt this method which is proposed by the International Geographical Union's Commission on Agricultural Typology, on tahsil level to classify and identify agricultural types found in the Vindhyanchal-Baghelkhand region, Madhya Pradesh, India. It incorporates Rewa, Satna, Sidhi, Shahdol, Sarguja, Jabalpur, Mandla, Balaghat, Seoni, Chhindwara, Narsinghpur, Damoh districts and Pawai tahsil of Panna district. All the 42 tahsils have been taken as thematic mapping units.

This study has been divided into twelve chapters. Geology, relief, drainage, physiographic divisions and climate have been described in Chapter I. Chapter II emphasizes different types of soils, their spatial distribution, fertility status and erosion. The cultural aspects dealing with the distribution of population, density, growth, sex-ratio, workers and non-workers, tribal and scheduled caste population, trend of urbanization and urban centrés along with mineral and industrial resources and transport network are dealt in Chapter III.

Chapter IV has been devoted to the study of landuse, a very common and important aspect for the study of agricultural base. For the analysis and interpretation of different categories of landuse, the method of orientation has been tested. In general, forest covers 39% of the area followed by cultivated land (38%), pastures

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(12.5%), barren (6.5%) and settlement and waterbodies (4%). This analysis has yielded 20 types of landuse orientations.

Further, orientation of cropped land has been presented in Chaprer V where they have been grouped into cereals, pulses and commercial crops symbolizing with letters C, P and O respectively. Further, they have been arranged into a formula where the letters indicate the group and number their ranks. Twelve such types of orientation have been found and mapped to explain their spatial distribution in the region. The above five chapters present a general picture of the area as well as the agricultural landuse which provides a basis in the typological analysis of agriculture.

The analysis of the agricultural variables begins with the Chapter VI and cotinues to Chapter IX. Twentyseven agricultural variables have been taken into account in the present analysis grouping them into 4 attributes.

Chapter X forms the core of the thesis and deals with the types of agriculture made on the basis of social, operational, production and structural attributes. All the variables have been given a code according to International classification and compared with the codes of World Types of Agriculture. In this analysis none of the recommened agricultural types is found in the area though some similarity on the third level is visible with that of Tmh, Tir, Tmc and Tmm.

But it does not fall in that type and thus it has been taken as a new type, i. e., Tmm_1. The main characteristics that differentiate this type from the International model types are very low to low mechanization, very low input of chemical fertilizers and irrigation, low productivity, medium commercialization, low level of commercialization and medium (sometime high) share of livestock product in commercial products. It has been further grouped on the fourth level for a definite characteristics type taking 5% deviation into account. This has provided two agricultural types, i. e., semi-commercial low productive mixed with prevalent livestock breeding (Tmm_1l) and semi-commercial low productive mixed with crops prevalent (Tmm_1c).

In Chapter XI five sample villages have been studied to support and test this system and also assess the applicability of the agricultural variables in analysing the agricultural typology. At the end, in Chapter XII the agricultural typology has been projected for the year 2001, considering the present state and future prospects in the advancement of agricultural inputs and outputs. This will add one new type (Tmm_2)

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on third level and three sub-types on fourth level, i. e., Tmm_2C_1, Tmm_2C_2 and Tmm_2Cf, representing irrigated, highly irrigated and fruit vegetable growing mixed agriculture respectively.

COLLECTIVIZATION OF RURAL SETTLEMENTS IN SINJAR REGION : A GEOGRAPHICAL STUDY

Taha Hamadi Obeid Sup. : *Dr. A. S. Jauhari*

Sinjar region of north-western Iraq, largely inhabited by the Yezidi community, has been a problem area because the supply lines of weapons to the rebellious Kurds passed through it. Moreover, it has great strategic importance as it has common border with Syria.

The area of study is restricted to eleven collectivized rural settlements which are distributed in two Qadhas (Tahsil). Eight of them are in Sinjar Qadha. They are Hettin, Al-tamim, Al-qadisiya, Al-yarmok, Al-andolus and Al-auroba in Al-shamal Nahiya (Block), and Al-bath and Al-walid in Al-qirawan Nahiya. The other three new villages viz. Al-adnaniya, Al-qahtaniya and Al-jazira are located in Al-qahtaniya Nahiya of Al-baaj Qydha. All these villages together have an area of 1,542 km² (36°7′58″36°33′47″ N. lats and 41°17′ and 42°1′40″ east longitudes) and a population of 58,384 according to 1977 Census.

Topographically, the region consists of three physical units : Sinjar mountain (Jabal Sinjar), Jabal Sinjar foothills and the alluvial fan plains. The climate of Sinjar region is generally semi-arid (BSh) lying between the arid desert climate (BWh) in the south-west and Eastern Mediterranean climate (Csa) in the Zagrous mountains in the north-east of Iraq. In summer the dominant north-westerly winds (shamal) bring, extreme drought conditions to the region. July and August are the hottest months, the mean monthly temperatures being 33.8°C and 33.7°C respectively. In winter the prevailing winds are still westerly with their procession of cyclones which bring moisture and cooler weather, the mean monthly temperature of January being 6.2°C. The minimum temperature at times falls a few degrees below freezing point at night.

The average annual rainfall 1941-80 is 40.33 cm and the number of rainy days is only 70 in a year. The rain increases to a maximum of 7.38 cm in December and 7.29 cm in January due to the increase in the number of cyclones.

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There are two types of vegetation : Mediterranean and steppe.

Two categories of soils : (i) loamy soil on the alluvial fan plains, and (ii) hapluxerollic on the mountain are present in the region. Generally, most loamy soils are suitable for yielding various kinds of cereal crops, vegetables and fruit, in areas with sufficient water facilities. This soil covers over 62% of the total area. The hapluxerollic soils cover 38% of the total area. They are useful for pastoral farming and forestry.

The surface water resources of the area are not of much importance as they are limited to temporary flows during rainy season. It is, however, the groundwater which is of great significance in the proper utilization of the land. The groundwater appears in three forms ; springs, kahrez and wells.

According to the 1977 census there are three groups of rural population on the basis of different faiths ; Christianity, Islam and Yezidi. The Yezidi sect formed the majority group with 55,942 i. e. 95.82% of the total population. Most of them migrated from Al-sheikhan region to Jabal Sinjar at the heel of religious persecution under the yoke of Ottoman empire two and half centuries ago while the others migrated from outside the country viz. Turkey and Syria. The Muslim group consisted of 2430 persons comprising 4.16% of the total population while there were two Christian families only.

The availability of groundwater and arable land were the basic geographical factors which determined the site of rural settlements. The increase in scattering of rural settlements meant a decrease in the distance both between the villages and between the dwellings of the farmers and their lands which depended either on rain or irrigation.

The Revolution of July 17, 1968 under the leadership of Arab Bath Socialist Party made an intensive effort to develop the agricultural sector by the enforcement of new Agricultural Reform Law No. 117 of 1970. As a result the government has started gradually to apply the collectivization plan of rural settlements through co-operative farms which concentrate several small-sized villages and scattered dwellings into larger ones at new sites so as to provide their population better public welfare services.

From the view point of Bath Socialism the provision of security in Sinjar region was one of the most important prerequisites for the success of developing Yezidi rural society. This led the government to take a decision in 1975 to shift 125 villages and some nomadic families that were scattered over the Jabal Sinjar.

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The sites of new villages are not centrally placed within their regional boundary but lie almost in the fringe areas which are not very congenial to regional activities of the farmers. In a few cases, the local authorities have chosen either a single site for two village, or the new village settlement lies outside the village fields. Thus the distance between the dwellings of most farmers and their fields become quite long, ranging from about 5 to 30 km.

The collectivization scheme is not without drawbacks ether in the choice of suitable sites for new villages or in settling the population of some old villages in the new ones that are not located near their lands. Thus 2,315 families comprising 18.38% of the total (12,589) families, have not got a chance to settle near their land due to security reasons because settling them apart from one another was possible solution to avoid tribal disputes and quarrels which often created insecurity in the region.

The Directorate of Planning and Follow-up distinguished the inhabited village from the scattered dwelling on the basis of the number of houses. The 1977 survey of rural housing considered any rural dwelling with minimum ten houses as an inhabited village, and any dwelling with less than ten houses was considered as scattered housing. But the rural settlements in Sinjar region can be classified into two : the isolated dwelling and the village. A village may be regarded as an assemblage of houses/families ranging from ten in number to a population of upto 5000 persons who solely depend on agricultural activity. On this basis there were 125 inhabited villages which were scattered in the area of 66 villages.

As the small villages need large amount of expenditure in providing social services, the authorities in rural areas emphasize that the village must have a minimum population of 2,000 persons in order to provide maximum social services economically. The implementation of collectivization programme as on 1975 caused a radical change in the size of old villages. The new villages appeared as agro-towns where the population ranged from 2217 persons in Al-auroba to 8110 persons in Al-qahtaniya.

The rural population depends for their livelihood on two kinds of activities : (i) the agriculture as a basic occupation for more than half of the rural population within their lands, and (ii) seasonal occupation such as building construction, manufacturing and welfare services wherever available in the country.

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In 1975 the Agriculture and Agricultural Agrarian General Committee in Sinjar initiated eleven co-operative farms in the eleven new villages. These co-operative farms have 9,743 co-operative farmers having at their disposal 116,662.75 ha of cultivable area. All of them exploit the land according to agricultural plan which was drawn up by the above committee. These co-operatives are responsible for : (i) renting the agricultural machines on fixed rate from Public Maintenance and Working Stations as well as from private sector, (ii) getting the farmers loans from the Agricultural Bank; (iii) marketing 60 per cent of the produce to pay the cost of production and giving the remaining 40 per cent to their members for home consumption, and (iv) spreading the ideology of Arab Bath Socialist Party among the farmers.

There are three main categories of land in the co-operative farms : (i) The arable land covers 116,662;75 ha or 65.09% of the total area; (ii) The grazing land covers 59,654.75 ha i. e. 28.70% of the total area, and the remaining of non-arable land "metruka" which occupies 12,955.5 ha or 7.23% of the total area. It includes the roads, residential land, cemeteries, and rocky land. On the basis of water resources the cultivation is classified into two principal patterns; (i) rainfed cultivation and (ii) irrigated cultivation.

The rainfed cultivation covers 112,596.25 ha comprising 96.51% of the total arable land which depend mainly on winter rainfall. It is noted also for its small variety of cereals and fruit orchards. Wheat and barley jointly cover 110,408.75 ha or 94.63% of the total arable land, but the cultivated area ranges from 60-70% and the rest is left as fallow which is ploughed only in the end of rainy season to increase the soil fertility and soil moisture reservation. Wheat occupies first place in area and in value. It covers about 60% of the cereal cultivated area while the barley occupies second place both in area and in value. Its fields spread over about 30% of the total cultivated area of cereals. Evidently most of the lands under rainfed condition receive less than 40 cm rain annually which is inadequate for proper cultivation of wheat and barley. The fig orchards and vineyards are mostly spread over 2,187.5 ha along terraces of mountain villages.

The overlapping of pastoral land in the foothills of Jabal Sinjar with the wheat and barley zone in the alluvial fan plains is well suitable for grazing sheep and goats. The rearing of livestock in the co-operative farms is still in its initial stage. Out of eleven co-operative farms only Al-tamim and Al-yarmok have embarked on rearing

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sheep. The private sector has small flocks of sheep and goats, which are used almost for home consumption. The herds of sheep and goats were greatly affected by the collectivization plan. It is estimated that more than 25% of the sheep and goats were sold since 1975 because the sites of new villages were far away from pasture land in Jabal Sinjar.

The result of field study which covered 377 families as samples shows that 102 families (27.06%) depend mainly for their livelihood upon agricultural activity: 100 families (26.52%) are engaged simultaneously in farming, construction works and other services. But their income from agriculture is lower than that from other activities. The remaining 175 families (45.42%) are landless and they are engaged in various occupations. The average monthly income per sample family is 28.9 dinars.*

Till 1975 the rural community of old villages did not enjoy welfare services for several reasons such as (i) the insecurity in Sinjar region; (ii) the isolated and scattered pattern of rural settlements; (iii) the scanty population of village—46.4% of the total villages had less than 251 persons each and (iv) the semi-nomadic life of some families who alternated their movement between the grazing zone on the foothills of Jabal Sinjar and the cereal zone on the alluvial fan plains. The official statistics show that primary schooling was available in only 23 villages (18.4%) with 3089 pupils in 1974-75 while the health services were restricted to eleven villages only. Thus the majority of rural population did not have the facilities for schooling and health services. Moreover, electricity was not available in any of the villages. These were among other factors that led the government to implement the collectivization plan to provide the population of new villages with better welfare services like, housing, education, electricity and water supply, health, transportation and communication, shopping and other services.

The planners chalked out the design of new villages; the welfare service-buildings were planned almost in the centre of the residential zone to make them easily accessible to the population. Each migrant family having a plot of 450 sq. m was assisted with 400 dinars by the government to build the house. The government, also constructed 10-21 modern houses per new village for the officers who work in welfare services. In 1977, there were 11,160 planned private houses

* One Iraqi dinar = $ 3.33

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distributed among the eleven new villages. All the private housing plots have uniform rectangular shape (30 m × 15 m).

It is thus evident that the collectivization programme of the rural settlements has greatly helped in bringing about an all round improvement in the socio-economic life of the people of the area within a short span of time.

To promote agricultural economy it is necessary to extend the irrigated land which requires : (i) Building small dams in the valleys wherever possible to store rain water and use it for agricultural and tourist's purposes; (ii) conducting the hydrological survey of groundwater reserves as a basis of exploitation of the groundwater economically.

Every effort must be made to introduce some industries like carpet making in the new villages either as household or co-operative activity as coarse wool and cheap labour especially of women are easily available. The availability of limestone, sand, gravels, and alluvial soil in Sinjar region are useful for manufacturing building materials like cement and dressed building stones.

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GEOLOGY

SEDIMENTOLOGICAL STUDIES OF PRECAMBRIAN ROCK FORMATIONS AROUND CHAMAKPUR, KEONJHAR DISTRICT, ORISSA WITH SPECIAL REFERENCE TO SANDSTONE AND CHERT

Sumit Kumar Ghosh Sup. : *Dr. B. K. Chatterjee*

The present investigation concerns with a sedimentological and petrographical study of Late Precambrian Kolhan siliciclastic rocks and chert associated with Banded Iron Formation (Iron Ore Group) developed around Chamakpur (85°29′, 22°01′), Keonjhar district, Orissa. The area under investigation covers an area of about 225 square kilometers, extending from Bhondgaon (85°35′, 22°05′) to Nayagarh (85°27′, 21°50′) of toposheet No. 73F/8 and 73G/5. It exhibits an extensive development of conglomerate and sandstone all along the western margin of the Singhbhum Granite.

The Kolhan Group lies unconformably over the Iron Ore Group and Singhbhum Granite and consists of impersistent conglomerates together with sandstones. The rocks are tectonically undisturbed and in general, exhibit westerly dip of 2° to 10°. The maximum thickness recorded is more than 45 meters near Chamakpur (85°29′, 22°01′), Inganijoran and Surgutaria in the central part, from where it gradually decreases towards the northern and southern portions of the basin. The differential thickening and thinning is mainly due to original basinal configuration, tectonically controlled by the NNE – SSW alignment of the Iron Ore Group synclinorium (Eastern Ghat strike). In general, the Kolhans show low dip near the Singhbhum Granite, which progressively increases westwards. Although its contact with the Banded Iron Formation in the west, is not exposed in the field, the sandstone in this part, exhibits some evidences of brecciation, criss-cross quartz veinlets, and high angle of dip, reflecting instability or tectonic disturbances. However, in the light of the 'geological cycle' concept of Harpum (1960), the Kolhan Group appears to represent an epeirogenic phase (basin and swell episode) of the Iron Ore Orogeny. As indicated earlier, the major portion of the Kolhans does not show any appreciable effect of the younger Singhbhum Orogeny. This may be due to its

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distance from the Copper belt thrust zone (nearly 90 kilometers away in NNE) and blanketing effect of the Singhbhum Granite craton.

The siliciclastic rock of the area mainly comprises interbedded conglomerate, sandstone and siltstone which exhibit varying types, scale and assemblage of primary sedimentary structures. Six lithofacies have been recognized on the basis of grain-size, sedimentary structures and bed geometry. They are granular lag sandstone facies (GLSD), granular sandstone facies (GSD), sheet sandstone facies (SSD), plane laminated sandstone facies (PLSD), rippled sandstone facies (RSD) and thinly laminated siltstone-sandstone facies (TLSD). The application of first order Markov- chain analysis of ten stratigraphic sections, has revealed the preferred upward transition paths for lithofacies changes as—

$$\begin{array}{c} \text{GSD} \searrow \\ \Uparrow \quad \text{SSD} \rightleftharpoons \text{PLSD} \rightleftharpoons \text{RSD} \rightleftharpoons \text{TLSD} \rightarrow \text{SSD} \\ \text{GLSD} \nearrow \end{array}$$

The value of chi-square in majority of the sections, however, suggests that the geological processes ultimately operative in the deposition of the siliciclastic rocks were non-Markovian or independent in nature. The occasional scouring or erosional surfaces with granule layers in SSD, PLSD, diffused nature of contact between RSD and TLSD, hummocky cross-bedding, reactivation surfaces and sharp ridges or steps over granule surfaces in SEM photographs, indicate the probability of storm event in nearshore environment. Extensive reworking of sands during deposition is evidenced by the results obtained from the sediment trend matrix after McLaren (1981).

The lithofacies and apparent vertical thickness distribution together with regional and stratigraphic variations of grain-size parameters indicate a slight depression in the west-central part and a general paleoslope towards western portion of the depositional basin. The stratigraphic distribution of size parameters however, reflects varying environmental energy condition such as water depth, wave intensity or velocity of depositing currents. The bivariate statistical and textural parameters, shape of the cumulative curves, linear discriminant function analysis and packing parameters, all indicate interaction of fluvial and nearshore environments. The C – M diagram of conglomeratic granular lag and granular sandstone facies reflect its similarity with the basic pattern of alluvial fan deposits (Bull, 1972) whereas SSD, PLSD, RSD and TLSD facies indicate deposition in beach or nearshore environment approximately at 5 to 25 meters depth. The

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mean roundness--grain size plot exhibit sinusoidal relationship which suggests either a dual source of the sediments or extensive reworking during deposition. The latter appears to be more plausible in the present case.

The sandstones are texturally immature to mature whereas mineralogically they are mature to supermature. The textural inversion commonly shown by them appears to be due to diagenetic origin of a part of the matrix or mixing fluvial and beach sands during a storm.

The vector means calculated from grain orientation and sedimentary structures reveal the operation of atleast three paleoflow systems namely south-west, north-west and north-easterly directions in almost all lithofacies of the siliciclastics. The relative vector strength however, varies laterally and vertically in these lithofacies, reflecting variation in flow regimes during deposition. In granular lag and granular sandstone facies, the paleocurrents are mostly SW and NW directions with dispersion lesser than 4000 and run parallel to lenticular or wedge-shaped sand bodies. This indicates fluvial influence during their deposition (Long and Young, 1978). The sheet sandstone facies, plane laminatad sandstone facies, rippled sandstone facies, and thinly laminated siltstone-sandstone facies, on the otherhand show predominance of NW and NE components with dispersion more than 6000, reflecting on-shore directed storm-influenced marine currents.

As stated earlier, the conglomerates (GLSD) are mostly polymictic towards northern part of the basin as well as basal part of the sequence. They are more oligomictic towards southern part and upper portion (GSD facies) of the sequence where they occur as thin layers and are mostly reworked. They are horizontally bedded cobble to pebble conglomerates, grading vertically into sandstones. They show vertical and lateral variations in degrees of matrix support, occasional imbricated pebbles diping more than 25°, subangular and subrounded clasts, approximately radial paleocurrent patterns, widespread occurrence of wedge-shaped conglomerates normal to paleoslope, lateral facies changes, and absence of debris flows, suggesting deposition in humid alluvial fans, or laterally coalescing fan complex between a mountain front and the sea. The pebbles and cobbles in the conglomerates are mostly granite, red jaspers, banded hematite jasper, hematite, feldspars, smoky quartz, garnetiferous quartzite, fuchisite quartzite, cherts and basic rock fragments. Traces of siltsize gold particles occur in the intersitial matrix. The overlying sandstones are mostly quartz or sublithic arenites. The heterogeneity of clasts composition together

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with the paleocurrent directions, suggest polygenetic nature of the provenance rocks. The shoreline was towards the margin of the Singhbhum Granite craton and sediments were derived mainly from the Singhbhum Granite-gneiss, Lower lava, Banded iron formation and Older metamorphics. This is also corroborated by the plot of quartz types in sandstone after Basu et. al. (1975). The association of a few fresh feldspars together with weathered types further suggest short fluvial transport and rapid deposition under humid climatic condition. This is also supported by occasional weathered profiles in Singhbhum Granite terrain. The banded hematite jasper and bedded chert mainly constitute the Banded Iron Formation (BIF) of Iron Ore Group exposed all along the western part of the basin. The BIF is mainly composed of oxide facies of Lake Superior type and is unmetamorphosed. The presence of sedimentary structures like parallel laminations, mud cracks, intraformational brecciation, convolute laminations with total absence of terrigenous materials suggests that BIF was formed as a chemically precipitated gel in shallow marine environment. The presence of stromatolitic laminations and bacterial remains in cryptocrystalline silica bands further implies the influence of biogenic activity during colloidal precipitation. Diagenetic differentiation of pure silica and iron oxide bands is also revealed by the study of Markovian matrices. The following upward transitions or cycle appears to be probable at 90th level of significance for 3 degrees of freedom.

Silica facies → Mixed facies → Iron oxide facies → Silica facies

Scanning electron microscopic study (SEM) of jasper band has revealed two dominant surface textures namely spongy and granular with all gradations between the two. The most important feature observed in BIF is the presence of numerous leached out micro-cavities produced during the supergene enrichment of iron ores.

To sum up, the present investigation reveals that Kolhan conglomerates and sandstones were deposited in high energy environment of a coastal complex near the margin of the Late Precambrian epeiric sea. The vertical and lateral arrangement of different lithofacies with their characteristic general upward fining sequence suggests the superimposition of retrograding shore-line features on the earlier prograding humid alluvial fans-sandflat complex. The distribution of lithofacies and depositional environments may be comparable to some extent with the present day transgressive or storm dominated high energy sedimentation along Atlantic shoreline of eastern North America.

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MINERALOGY AND PETROLOGY OF THE AREA AROUND GANGUVARPATTI, MADURAI DISTRICT, TAMIL NADU

Anand Mohan Sup. : *Dr. R. K. Lal*

The Precambrian Shield of South India displays progressive regional metamorphism from greenschist to granulite facies from north to south in Karnataka and Tamil Nadu. The E-W trending facies boundaries transect the regional northerly structural trends of rocks of Dharwar Super Group (~2.9 to 2.6 b. y.)

The area around Ganguvarpatti, district Madurai, Tamil Nadu constitutes a part of the granulite facies terrain of the South Indian Shield, and is characterized by the occurrence of varieties of rock types, viz. charnockites, enderbites, leptynites, khondalites, granitic gneisses, garnet-sillimanite-biotite gneisses (±cordierite), silica-deficient granulites containing assemblages including orthopyroxene, garnet, spinel, cordierite, gedrite and sapphirine; basic granulites (garnet-free, two-pyroxene-bearing assemblages with or without hornblende; ultrabasic granulites and quartzites. These lithological units belong to the older khondalite Group (or Sathyamangalam Group) and younger charnockite Group of Eastern Ghat Super Group. Two-phases of deformation (D_1 and D_2) have been recognized in the area around Ganguvarpatti, and earlier ENE-WSW trending folds (F_1) with foliation dipping due north between 30°-60°, and later cross-folds (F_2) trending NNW with a plunge towards north. The latter corresponds to the regional NNW trending folds that affected the rocks of Dharwar Super Group in Karnataka.

Textural study of the time relationships between the metamorphic crystallization and the two-phases of deformation suggests that metamorphism initiated during D_1 with formation of prominent foliation defined by biotite and/or sillimanite in pelitic-quartzofeldspathic assemblages and hornblende in the basic granulites. The crystallization of garnet took place during the static phase between the D_1 and D_2 deformations. This syn-to post-kinematic metamorphic crystallization related to the D_1 deformation may be attributed to an earlier episode of upper amphibolite facies metamorphism (M_1~2.9 - 3.0 b. y.) during which widespread partial anatexis and migmatization occurred resulting in the formation of Peninsular gneiss complex. Granulite facies metamorphism (M_2~2.6 b. y.) which has been superposed on M_1 episode, is essentially post-kinematic with respect to the D_2-deformation during which cordierite, orthopyroxene, sapphirine, spinel

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and clinopyroxene formed and thorough recrystallization resulted in the characteristic granoblastic fabric for most of the granulites. Partial retrogression of orthopyroxene to gedrite, garnet and orthopyroxene to biotite, and pyroxene to hornblende presumably took place during cooling following M_2 metamorphism (Proterozoic ?).

The mineral chemistry, distribution of elements in coexisting mineral pairs, phase-petrology, metamorphic conditions and petrogenesis of charnockites and the silica-deficient granulites are discussed in detail on the basis of 170 electron microprobe analyses obtained from nine rock samples of the area and 21 bulk analyses of the rocks.

The relative X_{Mg} (Mg/(Mg + Fe^{++})) in the co-existing minerals varies in the order : cordierite > biotite > sapphirine > orthopyroxer > gedrite > garnet ≥ spinel, in agreement with other areas of granulite facies metamorphism. The garnets contain upto 64% almandine, 50% pyrope and the contents of spessartite + grossularite is less than 10% Garnet (X_{Mg}, 0.28 – 0.52) and cordierite (X_{Mg}, 0.85 – 0.91) are rather homogeneous, although weak Fe - and Mg-richer rims have been observed in them respectively. The X_{Mg} of biotites (0.68 - 0.86) is affected significantly by the hetrovalent substitution of Ti and Al^{VI} in the octahedral site. The high TiO_2 - contents of biotite (up to 6 wt.%) and hornblende (up to 2.7 wt.%) from TiO_2 saturated assemblages is consistent with analytical data of these minerals from other granulite facies terrains. The sapphirine from the silica-deficient granulites have intermediate composition between $sapphirine_{2\cdot2\cdot1}$ and $sapphirine_{7\ 9\cdot3}$, and these are amongst the most iron-rich type resorted so far. The Mg Vs Al^{VI} and Al Vs Na plots of gedrite suggest tschermakite and edenite types of substitutions. The TiO_2 - contents of gedrite (upto 1.25 wt.%) are significantly higher compared to those occurring in the amphibolite facies metamorphism of other areas. The spinels are spinel-hercynitemagnetite solid solutions with X_{Mg} ranging between 0.38 to 0.72. The orthopyroxenes occur in the silica-deficient granulites and the basic granulites of the area, and these have higher X_{Mg}, Al_2O_3, and lower CaO from the former rocks compared to those from the latter rocks. Al^{VI} - contents of the orthopyroxene show a negative correlation with X_{Mg}. The clinopyroxenes lie in the field of saline and their X_{Mg} is higher than co-existing orthopyroxene and hornblende (pargasite).

The partitioning of different elements in co-existing mineral pairs suggests equilibrium crystallization during the thermal peak of granulite facies metamorphism followed by reequilibration during cooling and retrogression.

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The phase relationships, and metamorphic reactions have been studied in the model systems of $SiO_2 - Al_2O_3 - FeO - MgO - K_2O - Na_2O$-$CaO - H_2O$ in different combinations for the rocks of varied bulk compositions. Several petrogenetic grids have been proposed based on Schreinmakers analysis, to display the sequence of prograde and retrograde reactions during metamorphism. The co-efficients of reactions in the grids have been calculated through modified computer programme 'REACTION' after Finger and Burt, 1972. The microprobe data of minerals are plotted in the AKF, AFM and ACF diagrams for charnockites, leptynites; cordierite-garnet-sillimanite gneisses; and basic granulites respectively. The silica-deficient granulites are depicted in a projection from albite on to the $SiO_2 - (FeO + MgO) - Al_2O_3$ plane of the $SiO_2 - (FeO + MgO) - Al_2O_3 - Na_2O$ tetrahedron, and also in three newly proposed projections viz. spinel, sapphirine and orthopyroxene projections in the system $SiO_2 - FeO - MgO - Al_2O_3 - Na_2O$. Several prograde and retrograde metamorphic reactions have been suggested on the basis of discontinuity in topology of different projections and observed textural relationships. These include :

$$\text{Biotite} + \text{quartz} \rightleftharpoons \text{orthopyroxene} + \text{potash - feldspar} + \text{garnet} + H_2O \quad (1)$$

$$\text{Biotite} + \text{sillimanite} + \text{quartz} \rightleftharpoons \text{garnet} + \text{potash - feldspar} + \text{cordierite} + H_2O \quad (2)$$

$$\text{Garnet} + \text{sillimanite} \pm \text{quartz} \rightleftharpoons \text{cordierite} \pm \text{spinel}_{ss} \quad (3)$$

$$\text{Garnet} + \text{orthopyroxene} + \text{sapphirine} \rightleftharpoons \text{cordierite} + \text{spinel}_{ss} \quad (4)$$

$$\text{Garnet} \rightleftharpoons \text{orthopyroxene} + \text{cordierite} \pm \text{sapphirine} \pm \text{spinel} \quad (5)$$

$$\text{Sapphirine} + \text{orthopyroxene} \rightleftharpoons \text{cordierite} + \text{spinel} \quad (6)$$

$$\text{Hornblende} + \text{quartz} \rightleftharpoons \text{orthopyroxene} + \text{clinopyroxene} + \text{plagioclase} + H_2O \quad (7)$$

The reactions valid for different rocks are : (1) charnockites and enderbites, (2) khondalites, leptynite, garnet - sillimanite gneisses ($\pm$cordierite), (3) cordierite - garnet - sillimanite - bearing gneisses, (4), (5), and (6) for silica - deficient granulites and (7) for the basic granulites. The reaction (5) and (6) resulted in the formation of spectacular symplectites of orthopyroxene-cordierite sapphirine and orthopyroxene-cordierite-$spinel_{ss}$ rimming corroded garnet, and corona rims of spinel between sapphirine and cordierite grain contacts. The hydration reaction through reversal of the reaction (1), (2) and (7) are clearly evident from textural relations.

The metamorphic conditions during the thermal peak of metamorphism in granulite facies conditions have been estimated through experimentally determined mineral equilibria corrected for the reduced activity

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of water and through application of the models of geothermobarometers including four newly proposed models, alibrated from thermodynamic and experimental data, in this study viz. equilibria involving garnet - cordierite – orthopyroxene – quartz, garnet - cordierite – orfhopyroxene – spinel, sapphirine - orthopyroxene - spinel - cordierite (geobarometer) and garnet – orthopyroxene (Fe^{2+} – Mg) in K calibration (geothermometer). These suggest temperature of $800^0 \pm 50^0$C, pressure of 6 – 7 Kb $\pm$ 0.5 Kb, and $P_{H_2O} < P_{total}$ with activity of water $X_{H_2O} \sim 0.3$. The re-equilibration, however, continue during cooling, and "cut off" temperatures during which the exchange reactions ceased, varied in different mineral pairs. A comparison of the PT estimate of the area with other areas of granulite facies belt of South India reveal that although temperatures of metamorphism were similar, the P condition was 2 - 3 Kb higher in the northern part (Nilgiri, Shevaroy Hills etc.). This difference in P conditions is reflected in the common presence of cordierite in pelitic quartzofeldspathic assemblages and absence of garnet in the basic granulites of the area around Ganguvarpatti. The pressure difference may be attributed to different erosion level presumably related to block uplift associated with Shear-zones and lineaments.

It has been proposed, on the basis of field relations, petrography, phase-relationship, bulk rock chemistry including REE and experimental data, that the charnockites are formed from the granitic gneisses (Peninsular gneiss complex) through the reaction (1) under condition of reduced activity of water. With an increase in X_{H_2O} in the fluid phase the charnockites are transformed into gneisses through the reversal of the reaction (1). The sapphirine-bearing and sapphirine-free silica-deficient granulites are unusual in bulk composition (rich in Al_2O_3, FeO and MgO, and poor in Na_2O, K_2O, CaO and SiO_2) and chemically do not correspond to any normal igneous or sedimentary rocks. It has been proposed that these granulites are of 'restite' origin due to removal of granitic melt which resulted in relative enrichment of alumina and ferromagnesian constituents. The 'restites' containing garnet – gedrite assemblages were formed during M_1 episode, were again mefamorphosed under granulite facies condition (M_2) with the formation of orthopyroxene + $spinel_{ss}$ from gedrite and orthopyroxene + cordierite $\pm$ sapphirine $\pm$ spinel symplectite from the breakdown of garnet through the reaction (5).

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SEDIMENTOLOGICAL AND MICROBIOTIC STUDIES OF THE VINDHYAN SEDIMENTS, EAST OF SUSNAI, SON VALLEY, DISTRICT MIRZAPUR, U. P.

Bajarangi Sup. : *Dr. R. M. Singh*

(1) The area under investigation consists of Semri and Kaimur Group of rocks. The Semri Group is represented by Aurangi Formation (conglomeratic breccia and brown quartzites) Kajrahat limestones, Porcellanites, Olive shales, Fawn limestones, Glauconitic sandstones and Rohtas limestones. The Kaimurs consist of Lower quartzites, Silicified shales, Susnai conglomeratic breccia, Upper quartzites, Bijaigarh shales, Scarp sandstones and Dhandraul quartzites.

(2) The Aurangi is the oldest Formation lying unconformably over Bijawars and older rocks. The relation between Semri and Kaimur Group of rocks is conformable.

(3) In all, fourteen formations are well exposed having east-west general strike and dips varying between 5^0 to 25^0 with a few exceptions.

(4) A number of structures are found in various formations. A minor reverse fault F_1F_1 occurs near the Hardi village at the base of Kajrahat limestones having a trend NNE-SSW. Another reverse fault F_2F_2 have been observed near Susnai. The folding is common in Kajrahat limestones and Porcellanites. The Glauconitic sand-stones, Lower quartzites, Silicified shales and Bijaigarh shales are also characterised by minor folds.

The ripple marks, cross stratification, mud cracks and rain imprints are found in Glauconitic sandstone, Lower quartzites Upper quartzites and Scarp sandstones. Cross stratification is very common in Dhandraul quartzites. Box structures are only found in Olive shales. The stylolites are restricted Kajrahat limestones, Porcellanites, Fawn limestones and Rohtas limestones whereas the stromatolites are found only in the Fawn limestones.

(5) On the basis of the textural and mineralogical composition, the rocks of each formation have been classified. The Aurangi Formation consists of conglomeratic breccia and brown quartzites, which are actually sublith arenites. The Kajrahat limestones consist of microsparite and dolsparite. In Porcellanite formation there are porcellanites, tuffaceous lithic graywacke, glauconitic sublith arenites and quartz arenites. The Fawn limestones are actually Fawn dolostone and the Flauconitic sandstones are sublith arenites. The Rohtas

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limestones are mostly micrite and microsparite. The Lower quartzites, Upper quartzites and Dhandraul quartzites are quartz arenites whereas the Scarp sandstones are lithic graywacke in the lower part and quartz arenite in the upper part.

(6) The textural analyses of the different arenaceous units have been done by thin section method and the parameters have been plotted. It is apparent that the graywackes and arenites of the Semri Group are well sorted, dominantly negatively skewed, platy to mesokurtic in nature. The tuffaceous lithic graywacke and quartz arenites of Porcellanite Formation are mostly unimodal whereas Glauconitic sandstones are bimodal in nature The rocks of Kaimur Group are well sorted to moderately sorted (rarely poorly sorted), mostly positively skewed and leptokurtic to mesokurtic in nature. Almost all the formations are characterised by bimodal to trimodal and even polymodal sand grains.

(7) All the formations of Semri and Kaimur groups are poor in heavy mineral assemblage. Most common constituents are garnet, epidote, zircon and tourmaline together with chlorite, muscovite and staurolite. Others found in very minor concentration are kyanite, hornblende, chloritoid, rutile and barite.

(8) The Scanning Electron Microscopic investigation reveals the occurrence of halite in Olive shales and K-feldspars in Glauconitic sandstones as analcime in Bijaigarh shales. The quartz grains in Glauconitic quartz are characterised by V-shaped pits, curved grooves and blocks with conchoidal pattern. Similarly, in Dhandraul quartz arenite the quartz grains have characteristic cavities, triangular etch marks together with solution channels.

(9) The representative samples of each formation have been analysed using modern methods of spectrochemical analyses. On the basis of the ratio Fe_2O_3/FeO, Na_2O/CaO, SiO_2/CaO and CaO/MgO, it appears that the initial concentration of the individual cations is responsible for their precipitation.

(10) As regards the trace elements Cr, Ni, Co, Ba and Li are in maximum concentration in Porcellanite, strontium in Rohtas limestones and scandium in Glauconitic sandstones. The Upper quartzites have maximum V whereas Bijaigarh shales are rich in Zr. Cu is in maximum concentration in Dhandraul quartzites and other elements have more or less uniform distribution. The abnormal concentration of Ba in Porcellanites is thought to be due to the diagenesis when the behaviour

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of Ba was controlled by potassium and manganese. Stontium, in general, has decreasing tendency in the sediments of younger age. Thus, its concentration may serve as an index to the period of diagenesis.

From the distribution of Indium and its affinity with Fe^{+3} and Mn ions, it appears that in sedimentary cycle it prefers Mn. Similarly, chromium has poor concentration in younger sediments. Lithium concentration in argillaceous sediments appears to confirm the observations of Horstman, 1957. Copper is more or less uniformly distributed in all the formations.

On the basis of the affinity of the trace elements with the organisms it has been observed that trace elements may serve as useful indicators about the existence of life in the past.

(11) The Vindhyans are rich in microbiotic assemblages. The majority of the biotic assemblage consists of the rich varieties of the fossil group algae and cryptarchs. Among these groups, fifteen genera and 23 species have been identified. In addition to these a number of unidentified forms have also been found which have distinct organic affinity. *Ten species and one new genus have been proposed to be new. Chitinozoa* cf. *Desimochitina has been reported for the first time from the Vindhyan sediments (Fawn limestones) of Son valley.* The assemblage of the Bijaigarh shales is quite different from rest of the formations. The algae is represented by both colonial and filamentous forms.

The stromatolites occur only in Fawn limestones These are collenia frequens Walcott and Stratifera. In general, their shape is cylindrical and the horizontal sections show excellent concentric lines of light and dark colours either of mineral matters or of algal mats.

(13) The Dhandraul quartz arenites and Scarp sandstones have been crushed, sieved and washed. The size fraction between 20 and 30 mesh has been used for making glass. It has been found that after proper treatments, these rocks can very well be used for the manufacture of the glass. Some of the purer varieties may even be used for optical glasses. This is a significant contribution of the author. *The occurrence of halite in the Olive shales is being reported for the first time from the* Vindhyans of Son valley and it needs further investigation and comparison with the salt pseudomorph shales.

(17) The age of the Vindhyans has been suggested by different workers from time to time as detailed in chapter X. The radiometric dating indicates the Vindhyans being less than 1400 m.y. to 910 m.y.

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On the basis of the microbiotic assemblage the age of the Vindhyans has been considered to be late Precambrian (1000 to 750 ± 100 m.y.). On the basis of the stromatolites the Fawn limestones may be 1300 to 1000 m.y. old. Thus, the age of Semri and Kaimur Group of the Vindhyan Supergroup is still full of controversy. The total period suggested on the basis of the different evidences happens to be about 1300 m.y. to about 600 m.y. On the basis of the evidences collected by the author, the age of the Semri Group may be late Precambrian and that of the Kaimur Group, it is Upper late Precambrian.

SEDIMENTOLOGICAL INVESTIGATIONS OF GOPAD RIVER SANDS WITH SPECIAL REFERENCE TO TEXTURAL BEHAVIOUR

Prakash Lal Sup. : *Dr. M. N. Mehrotra*

Sedimentological investigations of Gopad river sands with special reference to textural behaviour form the subject matter of the present thesis. This river rises from Sonhat (Lat. N23° 28′ : Long. E82° 48′) in district Surguja and after flowing for a distance of 210 km meets the river Son at Bardi (Lat. N24° 32′ : Long. E82° 26′) in district Sidhi. The entire drainage basin of Gopad enjoys a monsoon type of climate and is thickly vegetated.

The major lithological units exposed in the basin are Archaean, Bijawar, Vindhyan and Gondwana (G. S. I. Misc. Pub. No. 30, 1976). These are differentiated on the imagery due to variations in the photo characters such as form, tone, texture, drainage pattern and density of vegetation. The smaller units however, are only faintly marked within the major units in the imagery, however are easily demarcated in the field.

Archaeans are represented by older metamorphics-granite gneiss and associated basic intrusives. The Bijawar formation rests on granite gneiss in the central and eastern part of the area with a general trend ENE-WSW with steep dips towards south. These formations are unconformahly overlain towards north by a huge pile of Vindhyan sediments, while towards south they are overlain by Gondwana rocks occurring in faulted basins. Outlier of Vindhyan formations have been recorded within the Bijawar, south of the Son river.

The Gopad sands bear a variety of sedimentary structures. Ripple marks are the most common and exhibit different types viz. cuspate, sinuous, linear asymmetric ripples and also secondary ripples. Both

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parallel and low angle cross stratification are not uncommon. The polygonal shrinkage cracks and mud curls are frequently seen along the banks, particularly in the lower reaches of the river. Besides, tracks and trails are also seen along the river.

Gopad river sands were subjected to detailed textural analysis. The data obtained by sieve (ASTM) analysis was used to make frequency and cumulative curves, which revealed their bimodal to polymodal nature.

The size parameters viz. median, mean, sorting/standard deviation, skewness and kurtosis were studied by using the formulae of several authors viz. Kelley (1924), Trask (1930, 1932), Krumbein (1936, 1939), Otto (1939), Griffiths (1951), Inman (1952), Cadigan (1954), Folk and Ward (1957), McCammon (1962a), Friedman (1967). The median and and mean size values of the investigated sands correspond to the medium sand grade. However, few samples fall in coarse and fine sand categories. Further, the median and mean size values calculated after different authors are more or less identical. Following different authors the majority of the Gopad sands fall in moderately sorted to moderately well sorted and well sorted categories.

The inclusive graphic skewness values of the investigated sands vary from very negative skewed to positive skewed, however majority of the samples are negative skewed. With regard to kurtosis the investigated sands vary from platykurtic to very leptokurtic.

Channel bar samples are medium to coarse sands, moderately sorted to well sorted, and mesokurtic to very leptokurtic. The skewness however shows great variation from positive skewed to negative skewed.

The braided bar and point bar samples are medium sands, moderately well sorted and leptokurtic, however they differ in their skewness. The former is negative skewed while the latter shows variation in skewness values which range from positive skewed to negative skewed.

Natural levee samples are medium sands, moderately sorted, positive skewed and mesokurtic, however, a few samples are very coarse, well sorted and nearly symmetrical.

Deficiency of certain size grades has been noted in the distribution of sands. More prominent is the deficiency of 2-4 mm, others being in grade sizes 1/2 – 1 mm, and 1/8 - 1/16 mm. This scarcity of certain size grades in the Gopad sands may be attributed to one or more of the following causes :—

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(i) All sizes are not produced in equal quantities by breaking down of the source rock.

(ii) The sediments of certain size grades (particularly 2 – 4 mm, 1/2 – 1 mm, and 1/8 - 1/16 mm) are mechanically unstable and hence they disappear during transportation.

(iii) The material within the mentioned deficient classes were produced by weathering, but due to certain hydrodynamic reason they were never deposited.

The sediments of Gopad river show erratic behaviour with the distance of transport. There is no systematic variation in the size parameters viz. mean size, sorting, skewness and kurtosis with respect to distance of transportation. This is due to the mixing of sediments of different characters brought by the tributaries of the stream, change in the energy and competency of the transporting medium and other local factors, viz. gradient and velocity of stream, width of stream channel and intermittent flooding during monsoon.

Binary plots among significant size parameters have been plotted after Folk and Ward (1957) and these closely correspond to his Brazos river plots. The binary plots distinguishing the field of river sands from beach and coastal dune sands have also been made, wherein majority of the samples fall in the river field. The QDa versus SKa and QDa versus Md plots are also quite comparable to those of fluvial sands. The CM diagram emphasises the role of tractive current in the deposition of the Gopad sands.

The average median roundness, average mean roundness and average median sphericity and average mean sphericity decreases as the sediments become finer.

Investigations of the surface features of quartz sand grains by SEM reveals the presence of both mechanical and chemical features. The mechanical features viz. irregular pits, V-shaped depressions, straight and curved scratches, angular as well as rounded outline, are characteristic of fluviatile deposits However, the presence of conchoidal fracture, straight steps, arcuate steps, fracture plates/planes, straight scratches and angular outline speaks in favour of glacial environment. Thus it could be inferred that glaciation had effected the provenance or at least a part of it, and the glacial effected grains were later transported by fluvial agencies.

Chemical features observed are mainly generated by solution (etching) and precipitation and profusely develop in Pedologic and in recent near surface diagenetic environment.

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Petrographic examination supplemented in many cases by D. T. A. and X-ray studies, revealed the presence of various types of quartz-undulatory and non-undulatory monocrystalline quartz, polycrystalline quartz, chalcedony and chert; feldspars-orthoclase, microcline, albite, oligoclase, perthite and antiperthite micas-muscovite and biotite and rock fragments-sandstones, limestones, schists, granites, phyllites, quartzites, metadolerites.

The heavy mineral fraction consists of both opaque and non-opaques; the former includes magnetite, hematite, ilmenite, brookite, anatase and leucoxene while the non-opaque suite consists of zircon, tourmaline, rutile, garnet, kyanite, sillimanite, epidote, hornblende, staurolite, apatite and hypersthene.

On the basis of detrital assemblage a complex suite of igneous, sedimentary and metamorphic rocks is considered to comprise the provenance of these sands. This agrees well with the varying suite of rock types which are exposed in the Gopad basin, viz. Precambrian granite-gneiss intruded by basic dykes and sills, Bijawars comprising low to high grade metamorphic rocks, Vindhyans made up of porcellanites, sandstones, shales and carbonates and the Gondwanas comprising sandstones and shales. Further the presence of fresh feldspar reflecting cold conditions, as has also been suggested by several mechanical surface features observed on many quartz grains under SEM. The altered feldspars, however. indicate a warm and moist climate in the provenance. Thus it is postulated that during the vast span of time the climate in the provenance fluctuated.

CONTRIBUTION TO THE STRATIGRAPHY AND PALAEOBOTANY OF THE LOWER GONDWANA FORMATIONS OF THE RAJMAHAL HILLS; BIHAR

Bijai Prasad

Sup. : *Dr. P. K. Maithy (External)*
Dr. V. D. Shukla (Internal)

The present investigation has been undertaken to demarcate the different lithological units of the Lower Gondwana succession and their stratigraphic positions on the basis of field and Floristic (Megaflora and Mioflora) evidences.

To achieve the object, the Lower Gondwana sequences in Pachwara Coalfield (Bansloi Valley Coalfield) is undertaken which

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exhibit the best developed sections right from the Precambrian to Jurassic and is also situated in the central part of the Rajmahal Hills.

The geology, mega – and miofloral studies of the Lower Gondwana sequences of Pachwara Coalfield of Rajmahal Hills reveals the following facts :

(1) The Rajmahal Gondwana Basin trends north-south in contrast to the Damodar Basin trending *east-west* direction.

(2) The Lower Gondwana are exposed as scattered patches at the western flank of the Hill ranges in faulted contact with the Precambrian Metamorphics.

(3) Overlapping of different lithounits of Gondwana sequences to each other show satisfactory evidences that the surface was subjected to considerable denudation accompanied by small scale disturbances.

(4) The Lower Gondwana is represented by Talchir Formation, Barakar Formation, Pachwara Formation and Dubrajpur Formation, while Upper Gondwana represents the Rajmahal Volcanic Traps with intertrappeans *Ptilophyllum* bearing plant beds.

(5) Talchirs are almost absent in Pachwara Coalfield, however, well exposed in Brahmani & Gumani Valley Coalfield. The presence of 2 to 3 meter thick, locally developed conglomeratic and pebbly beds exposed in Bansloi River near Bargo, was mapped by Ball (1877) as Talchir Conglomerate, and is the lowermost member of the Barakar Formation, hence placed under the Barakar Formation.

(6) Barakar Formation is characterised by the coarse to median, white feldspathic sandstones, which at places are pebbly and generally crossbedded. Other lithologies include carbonaceous shales and coalseams. But coal seams are not workable because sandstone to coal ratio is 10 : 1 and Coal is of inferior quality.

(7) The megaflora of Barakar Formation represents the dominance of narrow meshed *Glossopteris*; with common occurrence of *Gangamopteris* and *Noeggerathiopsis* in lower part of Barakar, while Upper Barakar is represented by the narrow meshed *Glossopteris* and the appearance of *Schizoneura* and *Neomariopteris lobifolia* and other pteridophytes.

(8) Palynologically Barakar Formation can be divided into 3 assemblage zone :

(i) Lower assemblage zone is characterized by the *Potonieisporites, Parastriopollenites, Plicatipollenites Scheuringipollenites* and *Faunipollenites*.

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(ii) Middle Assemblage zone – is characterised by the *Scheuringipollenites, Faunipollenites, Ibisporites* and *Striatopodocarpites* with poor triletes.

(iii) Upper Assemblage Zone is characterised by *Densipollenites, Faunipollenites, Scheuringipollenites* and absence of Triletes.

(9) Mega – and miofloral evidence suggests Middle Permian age for the Barakar Formation.

(10) Pachwara Formation overlies the Barakar Formation in unconformable relation, and characterised by the Hard Red ferrugenous sandstones, Red ferrugenous shales, micaceous siltstones and Mottled Red clays with or without the lamination of carbonaceous matters.

(11) Megafloral spectrum of Pachwara Formation represents diversified type of plant megafossils. Occurrence of Sphenopsids and ferns are common; sphenopsids are represented by *Trizygia, Phyllotheca, Stellotheca* and *Schizoneura,* while ferns are represented by *Dizeugotheca, Dichotomopteris, Neomariopteris* and *Santhalia. Glossopteris* is represented by 17 species, of which 11 are broad mesh forms.

(12) Barakar Formation differs from Pachwara Formation in absence of sphenopsids and ferns;

(13) Miospores in Pachwara Formation show the overall dominance of *Densipollenites, Scheuringipollenites, Faunipollenites, Striatopodocarpites* and triletes with characteristic occurrence of *Indospora.*

(14) The mega—and miofloral contents reveal Upper Permian age for Pachwara Formation equivalent to Raniganj Formation. However, there is no lithological resemblance with Raniganj Formation. Hence the new name *Pachwara Formation* is proposed.

(15) Dubrajpur Formation overlies the Pachwara Formation in disconformable manner, and characterised by the Grity Sandstones, white shales and clay. Megafossil represents the common occurrence of *Phyllotheca, Neomariopteris, Glossopteris* and *Platyphyllum.* The miospores are absent in this formation.

(16) The megafloral evidence suggests the Upper Permian age. It may be slightly younger than Pachwara Formation, as it directly overlies upon it, representing the youngest Permian lithounit of Lower Gondwana in Rajmahal Basin.

(17) Absence of *Dicroidium* and *Lepidopteris* and nondominance of *S. gondwanensis* which are characteristic megafossils of Triassic, suggests the youngest Permian strata in this basin and the limit of Lower Gondwana.

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GEOPHYSICS

GEOELECTRICAL STUDIES FOR AQUIFER DELINEATION IN LOWER MANER BASIN OF ANDHRA PRADESH AND THE GANGES-TONS INTERSTREAM AREA OF UTTAR PRADESH

Prabhat Chandra Chandra

Sup : *Dr. R. N. Athawale** (*External*)

Dr. C. L. Singh (*Internel*)

Growing demands of water for irrigation, rural development, industries and urbanisation have necessitated systematic exploration and exploitation of groundwater on a large scale. Techniques of geophysical prospecting have been found useful for exploration of groundwater. Among the geophysical techniques, electrical resistivity method being economic and fast has got the widest popularity.

The purpose of the present study is to delineate the shallow and deeper groundwater zones in consolidated, semi-consolidated and unconsolidated formations, using the geoelectrical (direct current electrical resistivity) method of geophysical prospecting. Two areas in Andhra Pradesh and Uttar Pradesh have been selected. The area of Lower Maner Basin of Andhra Pradesh presents Archaean granites and gneisses, Precambrian dolomites, limestones, quartzites and shales, and the semi-consolidated sandstones, shales and claystones of Gondwana age. The other area is the Ganges-Tons interstream tract of Uttar Pradesh. It presents the unconsolidated Quaternary alluvial deposits, underlain by quartzitic sandstones of the Vindhyan age. The results obtained from the geoelectrical studies and the conclusion arrived at form the suject matter of the thesis.

The Lower Maner Basin is a socio-economically backward area of Karimnagar and Warangal districts, where development of groundwater resource is essential to increase the irrigation potential. The Ganges-Tons interstream area of Allahabad district fall in the southern marginal part of the Gangetic Plain. It is one of the drought prone areas of Uttar Pradesh.

Besides the delineation of the aquifers in these areas, the other objectives of the study are to ;

(i) delineate the subsurface geological structures,

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(ii) demarcate the extents of an artesian aquifer in an area in the Lower Maner Basin by close-grid electrical resistivity study,

(iii) assess aquifer parameter of the artesian aquifer in an area in the Lower Maner Basin from geoelectrical layer parameters,

(iv) demarcate zones for various depths of drilling in the Ganges-Tons interstream area, and

(v) co-rrelate the interpreted geoelectrical layer paramaters with the results of the boreholes drilled in these areas at sites recommended on the basis of electrical resistivity studies.

In the area of Lower Maner Basin the field work for resistivity studies comprised both resistivity sounding and profilin. Twentynine Resistivity soundings have been taken in the Ganges-Tons interstream area. The interpretational work involved the use of curve matching and linear filter techniques.

In Lower Maner Basin aquifers in the granites and pre-cambrian formations occur at shallow to medium depths. The deeper aquifers have been delineated in Gondwana formations. The subsurface disposition of geological units and aquifers have been studied by preparing the geoelectrical cross-section across the basin. Co-rrelations study of resistivity results with lithologs of boreholes, drilled subsequently, have been made.

The borewell at Koyyur and Yedlapalli in Lower Maner Basin tapping mainly the middle unit of Kamthi sandstones and at Dhanwada tapping the Kota sandstones and claystones are successful. The borewell at Kayyur is a flowing one. There is difference in potentiality of the aquifers encountered at Koyyur and Yedlapalli. To delineate the lateral extents of the aquifer and to determine the possible lithological changes responsible for the differences in aquifer potentiality a close grid resistivity survey has been carried out around Koyyur. The results of the soundings have been discussed through presentation of apparent resistivity maps, geoelectrical cross-sections, Dar-Zarrouk parameter maps, fence diagram and 'depth to aquifer' map. Besides these, the linear relationship between transmissivity and transverse resistance has been obtained to evaluate approximately the transmissivity values at other points in the area around Koyyur. The area around Koyyur for future groundwater development has been demarcated.

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The study of subsurface hydrogeological conditions of the Ganges-Tons interstream area has been done by preparing apparent resistivity maps, geoelectrical cross-sections, Dar Zarrouk parameters map, alluvial thickness map and fence diagram. A depression area in the underlying Vindhyan rocks in central part has been delineated. Based on these ttudies, areas suitable for various depths of drilling have been demarcated.

SOME ASPECTS OF ATMOSPHERIC ENERGETICS ASSOCIATED WITH DEPRESSION DURING INDIAN SUMMER MONSOON

Surendra Nath Pandey *Sup. : Dr. J. C. Chattopadhyay*

In the present study an attempt has been made to understand with the help of a Quasi-Geostrophic model how the atmospheric energetics behave during south-west monsoon of the Indian subcontinent, especially during the time of a depression. This has been done by computing the basic forms of energy, advection of energy terms, the generation of available potential energy and various energy conversions. While computing the energetics of the atmosphere the monsoon circulation is considered as a basic flow and the depression formed over the Head Bay of Bengal as a perturbation or eddy. The details of these studies constitute the six chapters of the present thesis. The whole material may be summarised as follows.

A brief review of the past work done to explain the energetics of the atmosphere has been described; how the solar heating maintains the general circulation of the atmosphere by generating available potential energy (APE); how APE is converted into kinetic enegy (KE), and how APE as well as KE are transformed from zonal to eddy form.

The equations governing the Quasi-Geostrophic model to generate the input fields u, v, ω, T and Q from geopotential height (Z) are elaborated. Contour height fields are smoothed using Shuman's (1957) nine-point space technique to filter the meteorological noise. Using these parameters the energetics of the model atmosphere have been computed. A brief description of the present model is also given.

The salient features of the monsoon circulations over the Indian subcontinent have been described. Two different cases namely strong monsoon epoch (Case I) and weak monsoon epoch (Case II) have been selected for the study of energetics.

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The results of the basic forms of the energy advection and generation of the APE, the vertical distribution and daily variation of the results of the case I and case II have been presented. It is observed that during strong monsoon period zonal as well as eddy available potential energy increases with the increase in the intensity of the depression, attains maxima during the mature stage and then decreases as the depression dissipates. Both zonal and eddy available potential energy is maximum at about 300mb surface which is also the level of maximum eddy activity. The kinetic energy also shows a similar pattern. It is maximum at 200mb surface which is the level of tropical jet stream. In weak monsoon condition zonal and eddy forms of the available potential energy do not show much variation. Kinectic energy follows the pattern of case I.

There is continuous generation of zonal available potential energy for both the cases. However, eddy available potential energy shows destruction upto mature stage of the depression giving generation in the dissipating stage for strong monsoon epoch. For weak monsoon case also, the zonal available potential energy shows generation throughout the life cycle of the depression. However, the eddy form of the generation was significant at 300mb surface during the initial stage, otherwise, it is almost insignificant.

During strong monsoon epoch, zonal flux was inward during the mature stage, reverse was the case during the initial and decaying stages of the depression. Eddy flux of the available potential energy was inward whereas for kinetic energy it was inward only during the decaying stage. For weak monsoon situation flux of the zonal form of energy was inward. An outgoing flux of eddy available potential energy was found during the decaying stage and that for the kinetic energy was during the mature stage of the depression.

The results of the vertical distribution and daily variation of various conversions and transformations have been discussed. The conversion of the available potential energy to kinetic energy reveals that during the mature stage zonal kinetic energy acts as a source to zonal available potential energy whereas, during the initial and dissipative stages, zonal available potential energy acts as a source to zonal kinetic energy for both the cases.

For strong monsoon case, eddy kinetic energy acts as a source to the eddy available potential energy upto the maturity of the depression, then during the dissipative stage the eddy available potential energy acts as a source to the eddy kinetic energy. Reverse is the

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case for weak monsoon situation. Such type of conversion is found to be maximum in the middle level of the atmosphere.

Transformation of the available potential energy shows that during the strong monsoon case eddy supplies available potential energy to the zonal flow and the transformation increases with the increase in the intensity of the depression.

For weak monsoon case, zonal flow supplies energy to the eddy except during the mature stage of the depression, although, the magnitude is less than that of the strong monsoon case. Contribution of the second term of the transformation C_{A2} was insignificant in both the cases.

Transformation of the kinetic energy shows that eddy supplies kinetic energy to the mean zonal flow throughout the life cycle of the depression for strong monsoon epoch, whereas during weak monsoon situation, especially during the initial stage basic flow supplies energy to the eddy. The contribution of C_{K2} was in general, less than that for C_{K1}.

The main conclusions of the thesis have been summarised in the last chapter.

SEISMOTECTONICS OF THE HINDUKUSH REGION AND ANALYSIS OF ITS EARTHQUAKES RECORDED AT GAURIBIDANUR ARRAY

Lalaji Yadav

Sup : *Dr. Avadh Ram*

A number of scientific investigations have been carried out in the past using observations from seismic arrays. Recent improvements in data recording and acquisition systems, developments in computer technology and sophisticated techniques for signal processing have made remarkable contributions towards the latest knowledge and present state of the art in the field of seismology. The Hindukush region has been the subject of extensive seismological researches especially during the last decade. Enormous seismic activity in the area, peculiar characteristics attributed to its focal zone, its tectonics and structural situation and the plate tectonics hypothesis have all contributed much in attaching global importance to this region.

Gauribidanur seismic array (GBA) located in southern part of the country provides an opportunity to analyse earthquake waves from

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the Hindukush region in a narrow azimuthal range and study of their seismic signatures congruously. Moreover, the source-receiver distance allows the elastic waves to traverse the upper mantle region having their deepest point of penetration around 600 km. About hundred earthquakes occurring in the Hindukush region were selected from the NOAA (NEIS)/ISC listings and their short period P-wave recordings at GBA were obtained. These events have similar epicentral distance ($22^0 \pm 3^0$) and narrow azimuthal ($350^0 \pm 40^0$) range from the array.

Observations on slowness (inverse of apparent velocity) and apparent azimuths of seismic waves made at recording stations are generally affected by the anomalous structures present in the vicinity of the source region, near the bottoming zone of the rays and beneath the recording sites. Thus, the deviations (anomalies) in the above parameters can be obtained from a spherical symmetric earth which are, sometimes, significant depending upon the nature of the causative structure. GBA is situated, in general, on homogeneous structures. However, it was found from the literature that a dipping plane coincident with Moho could explain the time residuals well at this array. Further, an azimuthal dependent structure near the array in a particular direction has also been reported in the past. Important results and innovations from the present research project are recapitulated in the following paragraphs.

A correction-table for slowness and azimuths of P-waves measured at GBA has been computed using different combinations of input parameters. P-wave velocities below and above the interface were taken as 8.0 km/sec and 6.5 km/sec respectively for all combinations. Computed corrections have been tested on the real data of lower mantle and it is found that a dipping interface having 6^0 dip and strike N 13^0 E, explains observations of ray direction anomalies in a satisfactory manner. This can deviate seismic rays upto 11.5% in slowness and 6.5^0 in azimuth.

Seismotectonics of the Hindukush region has been studied in detail. A fault zone dipping steeply (75^0) in the north-west direction and striking N 66^0 E has been investigated on the basis of the spatial distribution of earthquakes in two vertical planes through 68^0 E and 32^0 N. Focal mechanism solutions of seventeen earthquakes show thrust type of faulting along the nodal planes trending in NE and SE directions. Some of the solutions show small components of strike slip motions. The dip of the compressional axes rarely exceeds 25^0. Orientation of tensional axes in all the cases was found to be almost

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vertical. It may be interpreted that these earthquakes were caused by down dip extension within a sinking slab.

Slowness and azimuth anomalies for short period P-waves were computed using a standard earth model. Slowness anomalies of the order of 1.4 sec/deg and azimuthal anomalies of upto 6° have been found. These are presented in the form of an array diagram which does not show systematic mislocations. Both slowness and azimuth anomalies show a positive as well as a negative bias. However, azimuthal anomalies almost show a positive bias towards the north which indicates that most of the ray tubes have deviated northwards during their transmission path while reaching GBA. Slowness anomalies can be classified into two systematic patterns : one showing a highly positive bias above 10.0 sec/deg of absolute slowness value and the other showing a moderately negative bias below this absolute value. There are more rapid variations in the positive bias slowness anomalies than those in the negative bias. These anomalies are attributed to a structure present in the zone where the rays have their maximum penetration. An abrupt change in slowness pattern just before 23° epicentral distance (corresponding depth of about 625 km) suggests that the velocity gradients are much more pronounced around this depth as compared to the shallower depth. However, its value is increased further as one considers the sampled zone below a depth of 625 km. This implies the presence of three layers in the upper mantle (400-700 km depth range) beneath western India.

Several causes for complexity of P-wave signals originating in the Hindukush focal region have been investigated in this study. Visual search of the recordings of these earthquakes has revealed that most of the events occurring at shallower depths have complex signatures as compared to the deeper events. A positive correlation of complexity with magnitude is found. Spectral ratio measurements have demonstrated that complex signals are richer in low frequency energy contents. A number of theoretical seismograms for short period P-waves were computed and the analysis reveals that complexity increases with focal area but decreases with the increase in focal depth within certain constraints. The structure near the source region, complicated source functions and probably the scattering confined to the crust-upper mantle near source are mainly responsible for the complexity of the Hindukush earthquakes as the transmission zone of the ray tubes from turning point to the recording station is practically the same.

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DEVELOPMENT OF THEORY OF LINEAR QUADRUPOLE-DIPOLE RESISTIVITY SOUNDING TECHNIQUES AND GEOELECTRICAL INVESTIGATIONS FOR GROUNDWATER IN HARD ROCK AREAS OF VINDHYAN TERRAIN

Girija Shanker Yadav Sup. : *Dr. C. L. Singh*

The research work presented in *Part A* of the thesis is the development of the theory of linear Quadrupole-Dipole resistivity measurement system. This is one of the depth sounding techniques which measures the different components of electric field produced by the Quadrupole source situated over a stratified earth and the potential is measured by a Dipole placed at a large distance away from the Quadrupole source. In the derivation of the theoretical expressions for the apparent resistivities, the use is made of the Stefanesco's integral. A general mathematical expression which is representative of all the possible configurations for linear Quadrupole-Dipole system is obtained in terms of azimuth angle, the Quadrupole-Dipole separation and the layer parameters (i. e., thicknesses and resistivities). It is found that the mathematical expressions thus derived for the various linear Quadrupole-Dipole configurations are directly related with the Schlumberger apparent resistivity.

Further the approximate expressions are derived for obtaining the first and second derivatives of the Schlumberger apparent resistivity to obtain theoretical curves for linear Quadrupole-Dipole configurations. Subsequently the theoretical response of various linear Quadrupole-Dipole configurations over three layered H-and K-type sections have been computed using these expressions to show the effect of azimuth angle. The theoretical curves are presented for the various azimuth angles with varying thickness ratios which give an idea about the resolution of the newly developed system. A procedure for computing the theoretical apparent resistivity curves is also detailed in the text. Furthermore, it is observed that there is a similarity between the apparent resistivity curves for Azimuthal and Equatorial Quadrupole-Dipole curve. Explicitly, the resolving power of the linear Quadrupole-Dipole system is, in general, very high in comparison with other sounding techniques.

The work presented in *Part B* of the thesis is the geoelectrical investigations for groundwater in hard rock areas of Vindhyan terrain of Mirzapur district in Uttar Pradesh, India. Geoelectrical surveys were carried out mostly with Normal Schlumberger sounding technique, however, a few soundings were taken with Half-Schlumberger technique to study the applicability of the Half-Schlumberger sounding technique in hard rock areas. The results are correlated with

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the Normal Schlumberger sounding data and its limitations are discussed. It is observed that Half-Schlumberger technique is very useful in areas having A type or H-type resistivity sections with resistive substratum at comparatively shallower depth.

A brief account of the recent interpretational techniques of geoelectrical soundings has been given, and based on these interpretational techniques two computer programs in Fortran IV language are developed. The program 'GIMRES' (General Interpretation Model of Resistivity Sounding) computes the theoretical curves using digital linear filner methods, whereas the program 'AIMRESI' (Automatic Iterative Method of Resistivity Sounding Interpretation) is used for the automatic interpretation of resistivity sounding data using steepest descent technique.

Using Wiener-Hopf least square technique, new sets of filter co-efficients are determined for direct and inverse Schlumberger filters. These co-efficients are computed for sampling interval of (ln 10)/3.5. The results of application of new sets of filter co-efficients on theoretical models are compared with results obtained by the application of other existing filters which shows that these filters are more accurate and require less computer time for operation.

Altogether 78 geoelectrical soundings were taken which have been interpreted with the help of computerized techniques. The results are presented in the form of geological cross-sections to indicate the presence of aquifer or aquifer systems. It is found that exploitable groundwater is mainly confined in sandy layers, sandy clayey layers and also in fractured sandstones. A few cross-sections have been correlated with the available bore-hole data which reveal a general correspondence between them in regard to the lithological changes, subsurface geology and areal distribution of aquifers. Finally the results from a few spot soundings are also presented which indicate the presence of some localised interesting features in the region.

SOME STUDIES ON ANALOG AND NUMERICAL MODELLING IN ELECTROMAGNETIC PROSPECTING

Om Prakash Gupta

Sup. : *Dr. J. G. Negi** (*External*)
Dr. C. L. Singh (*Internal*)

Multifrequency electromagnetic method in geophysical exploration is a powerful technique to map the subsurface conductivity

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structures. It has been successfully used for the prospecting of sulphide deposits in Canada and Scandinavian countries for depths lower than 1 km. In tropical countries such as India, Australia, Brazil etc. the moderately conductive host and/or overburden pose a serious depth limitation and also complicate the geological interpretation of anomalies of electric and magnetic fields. The problem can be investigated by the use of EM laboratery models and/or numerical techniques.

The magnitude of an anomaly depends on source-receiver system, its frequency, conductivity, magnetic permeability, shape, size and orientation of the model. A qualitative and/or quantitative interpretation is based on comparison of observed field response (anomaly) with the responses that would be observed by the system over simple idealised models. The single most representative model has been the (thin) half-plane (representing the sulphide dikes) both for airborne and ground EM measurements. Even this simple model has not yet been fully explored for horizontal coplanar (Slingram) method in presence of conductive host and/or overburden.

The thesis contains systematic model studies to determine the response modification of planar model of different conductance ($\sigma.t$) with its depth extent, strike length and thickness in resistive/conductive host medium. It is found that a model with strike length and depth extent equal to or greater than 3.0 L and 2.5 L (greater for low conductance) respectively can be idealised as a half-plane, where L is the transmitter-receiver separation. Similarly the conductor with its thickness less than half of the skin depth should be considered as 'thin'. Such clear definitions invalidate som earlier model-result interpretations. In the presence of conductive host medium response modification over finite depth extent model is greater than that of half-plane in air. In contrast the response over finite strike length in insulating medium is more than in conductive medium.

The two different conductive overburden simulation model studies show positive shielding effect when the target and overburden are inductively coupled and response enhancement when the two are conductively coupled. A lateral inhomogeneity which is conductively coupled with the overburden shows quite a distinct signature in quadrature profile.

A comparative study of Inline and Broadside Horizontal Coplanar configuration shows that the latter is more diagnostic for delineating dip, strike direction of the model and the response of conductive host medium.

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Finite difference technique has been tried to numerically study the effect of depth extent and thickness of planar conductor in uniform field for E-polarization case. It has been found that for a conductivity contrast of 100 and at a frequency of 10 kHz a planar model with depth extent of 0.8 skin depth resembles a half-plane. Thumb-rule obtained here shows that the thickness of a half-plane model is equal to separation of two shoulder peaks in Hz profile and to the distance between the points of inflection of the Hy profile.

STUDIES ON LOVE WAVE PROPAGATION IN HETEROGENEOUS EARTH MODELS USING RAY THEORY APPROACH

Randhir Singh Sup. : *Dr. J. Singh*

A great deal of research has been carried out in the last two decades on surface wave studies which have made significant contribution towards our knowledge about the general nature of the crust and upper mantle. The earth is very complex, specially the anomalous regions such as continental-oceanic transition zones, mid-oceanic ridges, trenches and mountainous regions which exhibit inhomogeneity, anisotropy and dipping nature of the interfaces. In such cases it is difficult to carry out theoretical investigations because of the complexities involved in mathematical deductions and computations. Some efforts have been made to use the wave theory approach but for most of the complex earth models, incorporating inhomogeneity, anisotropy and dipping interfaces simultaneously, the wave equations do not reduce to standard differential equations making the solution of the problems intractable.

The work presented in this thesis is an endeavour to develop a comprehensive theory of Love wave propagation in different types of heterogeneous earth models representing the anomalous regions of crust and upper mantle, making use of ray theory approach, which has been found very suitable for the analysis. Besides its theoretical importance, the present investigation would go a long way in unfolding the nature of the anomalous zones, if integrated efforts are made in this direction.

In the present work Love wave dispersion equations have been derived using the principle of constructive interference of the ray and its wavefront, for the following four earth models :

(i) Laterally inhomogeneous crust lying over homogeneous mantle with dipping interface;

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(ii) Vertically inhomogeneous and transversely isotropic crust lying over homogeneous mantle with dipping interface;

(iii) Transversely anisotropic and laterally inhomogeneous N-layered earth model; and

(iv) Transversely isotropic and vertically inhomogeneous N-layered earth model.

Following conclusions emerge out from the close examination of the results :

(i) For dipping interface, the increase of lateral inhomogeneity causes a decrease in the phase and group velocity of Love waves towards higher frequency side whereas no such effect is observed towards low frequency side;

(ii) The effect of dipping interface is prominent on phase and group velocities of Love waves in the higher frequency side, whereas nominal effects are observed for lower frequencies;

(iii) The effect of parametric variations in lateral direction increases with the dip of the interface;

(iv) For dipping interface sharp cutoffs are observed on higher frequency side and small effects are observed on lower frequency side;

(v) The increase of vertical inhomogeneity causes a decrease in the phase and group velocities of Love waves;

(vi) The increase of lateral inhomogeneity in presence of anisotropy causes reduction in the phase velocity whereas the group valocity shows decrease in the lower frequency range and increase in the higher frequency range;

(vii) Anisotropy introduces rotational effect on the dispersion curves. The shifting is more pronounced on the lower frequency side than on the higher frequency side; and

(viii) The effect of lateral/vertical inhomogeneity, anisotropy and dipping interface is comparatively smaller on the first higher mode than on the fundamental mode.

The results presented in the thesis would find wide application in the interpretation of Love wave data in the anomalous regions of the earth. It is hoped that further theoretical studies accounting for the sphericity of the earth incorporating the complex nature of the medium would help in greater and finer retrieval of information from the observed surface wave data.

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MATHEMATICS

A STUDY OF CERTAIN PROPERTIES OF SPECIAL FUNCTIONS

Lal Sahab Singh Sup. : *Dr. S. N. Singh*

The thesis consists of five chapters. The first chapter comprises mainly of a brief historical account of unifications of the polynomials like the Hermite, the Bernoulli, the Euler, the Eulerian and the generalizations associated with them, by different aurhors. Unifications of special functions and polynomials have been arrived at by considering different ways of defining ways of defining them, such as generating relations, Rodrigues' formulae, Hypergeometric forms, operational formulae, Recurrence relations, Differential equations, etc. Considering these aspects, we have arranged different unifications given by various authors under different headings. We have concluded this chapter by giving a list of notations and a set of two lemmas of a general character.

Chapter 2 is devoted to the study of a polynomial set associated with generalized heat polynomial due to D. T. Haimo (1966). Associated polynomial set has been subjected to further investigations and several properties, such as explicit form, finite summation formula, generating functions and bilateral generating functions have been established. The chapter has been concluded by giving some series relations for generalized heat polynomials in terms of circular, hyperbolic and hypergeometric functions. The corresponding results for the ordinary heat polynomials of even order defined by P. C. Rosenbloom and D. V. Widder (1959) and the Hermite polynomials of even order are rendered intuitive.

In the first section of Chapter 3, we recall a recent theorem of Srivastava et al (1980) for obtaining bilateral and bilinear generating functions for a certain sequence of special functions and give a simple alternative proof. We then apply the theorem to a generalization of Laguerre polynomials and in the sequel Meixner's formula for Laguerre polynomials is deduced Section II is devoted to the further study of the generalized polynomials $G_n^{(\alpha)}(x, r, p, k)$ of Srivastava and Singhal (1971). We present certain applications of a class of bilateral generating functions for the said polynomials in deriving some new bilateral

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and trilateral generating relations. The section ends with a bilinear generating relation derived by using the operational technique. Finally in section III, the polynomials $V_n^{(\alpha)}(x ; a, k, b)$ due to Srivastava and Singh (1979) have been subjected to further investigation and a class of general bilateral generating relations are derived for the same. The first section of the present Chapter has appeared in Bulletin of the Institute of Mathematics Academica Sinica Vol. 10, No. 3, (1982), 233-237 while the third section has been accepted for publication in Indian Journal of Pure and Applied Mathematics.

The study of a new generalization $V_n^{p'}(x)$ of a certain class of polynomials considered by Srivastava (1976) forms the basis of Chapter 4. For these polynomials, we have investigated the explicit formula, the values of $V_n^{p}(o)$ and $V_n^{'}(o)$, differential formulas and a generating relation. A few recurrence relations for these polynomials have also been derived. On specializing the parameters, corresponding results for Braggs polynomials $g_n^{p}(x)$ have been noticed.

Chapter 5 consists of two sections. Section I is devoted to the further study of the polynomials $Z_n^{a}(x; k)$ due to Konhauser. For these polynomials we have established some generating relations involving Kampe de Feriet's double hypergeometric function and a general class of triple hypergeometric function. In the last section, a general class of polynomials relevant to quantum mechanics defined by Prabhakar and Jain is taken into account and some interesting results such as differential equations and asymptotic expansions have been established for these polynomials.

In the present work frequent use has been made of the notations and lemmas given at the end of the introductory chapter.

A STUDY OF EXTENDED BERNOULLI, EULER AND EULERIAN POLYNOMIALS

Vijay Shankar Rai Sup. : *Dr. S. N. Singh*

The thesis consists of six chapters followed by an Appendix.

Chapter 1 comprises of mainly a brief historical account of unifications of the polynomials, like the Legendre, the Laguerre, the Hermite, the Bernoulli, and Euler, the Eulerian and the generalizations associated with them by different authors. Certain methods for obtaining

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bilinear and bilateral generating relations and characterizations studied by different research workers have also been given. The chapter concludes with a list of notations and a set of two lemmas of general character.

In Chapter 2, after having defined an extended polynomial set P(n, h, k, a, b, m, i, j; x; y), whose study forms the basis of the present Chapter, numerous interesting results, such as, complementary arguments theorems, a set of recurrence relations, which are of both pure and differential types, finite difference formula and addition theorems have been established. It ends with a set of four multiplication theorems for the said polynomial set. It may be of interest to remark here that the said polynomial system unifies extended Bernoulli, Euler, Eulerian polynomials as well as corresponding numbers due to Carlitz

Chapter 3 deals with a general class of polynomials $J_n^{(m_1, m_2)}$ (x; y; a, s, b, c), in two variables, which can be regarded as novel extension of various generalizations of Bernoulli, Euler, Eulerian and other related polynomials studied by different scholars so far. For this class of polynomials, several interesting results, such as, differential recurrence relations, pure recurrence relations, complementary arguments theorem, expression for the said polynomials in terms of other polynomials, multiplication theorem, integrals and finite difference formulae have been deduced. It is observed that these functions happen to be solution of one-dimensional heat diffusion equation.

Chapter 4 consists of three sections. In Section I, we have defined a polynomial set $G^{(p)}_{n;h,w}$ (x; a, r, b), which is a unified treatment of generalized Bernoulli and Euler polynomials due to B. Nath. The generating relation technique has been used to obtain pure and mixed recurrence relations and many other properties, such as, series form, the relation between polynomials of successive orders, complementary argument theorem, integrals and multiplication theorem, etc. Multiplication theorem for the barred functions has been dealt with at the end. Section II is devoted to the study of a generalized polynomial set in two-variables which, in turn, yields the known generating relations defined in Section I by specializing parameters involved therein. Similar properties as those in Section I have been derived for the said polynomial system. In the third section an attempt has been made to present a k-variable extension of the polynomial $G^{(p)}_{n;\,h,\,w}(x; a, r, b)$

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studied in Section I. In course of this discussion we have obtained various properties of the aforesaid polynomials, such as, series form, complementary arguments theorems and multiplication theorem.

In an attempt to present a unified treatmemt of various generalizations of Bernoulli, Euler, Eulerian and other related polynomials, we define and study in Chapter 5 a general class of an Appell set $R_{-*}^{(q)}$ (x*; a, m, b) of order q in k – variables. A set of pure and mixed recurrence relations, complementary arguments theorem, finite difference formulae and multiplication theorem have been derived for the said polynomial set.

Like Carlitz, Srivastava, Singh, Joshi-Singhal and others, we have introduced and studied, in Section I of Chapter 6, the polynomials $A_n^{(\alpha)}$ (x; a, k, s), $T_n^{(\alpha,\beta)}$ (y; x; a, k, s) and $Q_n^{(\alpha,\beta)}$ (x; y; a, k, s) associated with a general polynomial set $V_n^{(\alpha)}$ (x; a, k, s) due to Srivastava and Singh. Thus an attempt has been made to unify the findings of the above mentioned researchers. Section II is concerned with the derivation of an interesting operational expression for the Laguerre polynomials and a natural generalization of it for the generalized Laguerre polynomials.

Finally, in Appendix we have considered the derangements in terms of Konhauser biorthogonal polynomials. For this we have established an interesting theorem concerning shift-number of a permutation. Our approach is purely combinatorial and depends on combinatorial interpretation of the integral involved.

CERTAIN PROBLEMS IN THE SUMMABILITY OF FOURIER SERIES AND ITS ALLIED SERIES

Jata Shanker Singh Sup. : *Dr. L. M. Tripathi*

The present thesis entitled "Certain problems in the summability of Fourier series and its allied series" is an outcome of my researches into the theory and applications of infinite series. It consists of seven chapters.

In the First Chapter, which is introductory, an attempt have been made to make a brief account of the existing results which have interconnections with my investigations.

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In 1978, Saxena and Prasad [4] obtained a result on the uniform Nörlund summability of the conjugate series of the Fourier series, in the following form :

If $\alpha(t)$ denotes a function of t, $\alpha(t)$ and $t/\alpha(t)$ ultimately increase steadily with t.

$\log n = O(\alpha(P_n))$, as $n \to \infty$.

and

$\psi(t) = o(t/\alpha(P_\tau))$,

uniformly in a set E, as $t \to +0$, then the conjugate series is summable (N, p_n), uniformly in E, to the sum,

$$\frac{1}{\pi} \int_{1/n}^{\pi} \psi(t) \cot \tfrac{1}{2}t \, dt,$$ at every point, where this integral exists.

where this integral exists uniformly in E.

In Chapter II, we have established a theorem for the uniform Nörlund summability of conjugate series of the derived series of a Fourier series, which corresponds to the result of Saxena and Prasad. More precisely we prove the following theorem :

If $\alpha(t)$ denotes a function of t, $\alpha(t)$ and $(t/\alpha(t))$, increase monotonically with t,

$\log n = O(\alpha(Q_n))$, as $n \to \infty$,

and

$$H(t) \equiv \int_0^t |dh(u)| = o(t/\alpha(Q_\tau)),$$

uniformly in a set E, as $t \to o$, then the conjugate series of the derived series of a Fourier series is summable (N, q_n) uniformly in E, to the sum

$$-\frac{1}{4\pi} \int_0^{\pi} h(t) \operatorname{cosec}^2 \tfrac{1}{2} t \, dt,$$ at every point x,

where this integral exists.

In 1959, Varshney [8], established a theorem for the $(N, \frac{1}{n+1})$, C_1 summability of Fourier coefficients, in the following form :

If

$$\psi(t) \equiv \int_0^t |\psi(u)| \, du = o\left[t/\log \frac{1}{t}\right],$$

as $t \to 0$, then the sequence $\{n B_n(x)\}$ is summable $\left(N, \frac{1}{n+1}\right)$. C_1, to the value $L(x)/\pi$, $L(x)$ being a constant, where L depends on x.

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In Chapter III, we have generalized the above theorem for the sequence of Fourier coefficients by $(N, p_n).C_1$ method, by replacing the particular sequence $\left\{\frac{1}{n+1}\right\}$ by a more general sequence $\{p_n\}$, which is a generalization of the theorem of Varshney. More precisely we prove the following theorem [5].

Let $\lambda(t)$ and $K(t)$ be two positive functions of t such that $\lambda(t)$, $K(t)$ and $\frac{t\lambda(t)}{K(t)}$ increase monotonically with t.

If

$$\psi(t) \equiv \int_0^t |\psi(u)|\, du = o\left[\frac{\lambda(1/t)\, p_\tau}{K(p_\tau)}\right],$$

as $t \to 0$, where τ denotes the integral part of $\frac{1}{t}$,

and

$$\lambda(n)\, P_n = O[K(P_n)], \text{ as } n \to \infty,$$

then the sequence $\{n B_n(x)\}$ is summable $(N, P_n).C_1$ to the value $L(x)/\pi$, $L(x)$ being a constant, where L depends on x and $\{P_n\}$ is a real, non-negative and monotonic non-increasing sequence such that $P_n \to \infty$, as $n \to \infty$.

In 1977, Tripathi [7] established a theorem for the Nörlund summability of Legendre series in the following from :

If

$$\int_0^t |f(x \pm u) - f(x)|\, du = o\left(\frac{p_\tau}{p_\tau}\right),$$

as $t \to 0$, then the Legendre series is summable (N, p_n) to $f(x)$ at an internal point x of the interval $(-1+\epsilon, 1-\epsilon)$, $\epsilon > 0$, where $\{p_n\}$ is a real non-negative and monotonic non-increasing sequence such that $p_n \to \infty$, as $n \to \infty$.

In Chapter IV, we have generalized the above theorem for the (N, p_n) summability of Legendre series in the following form :

If

$$\int_0^t |f(x \pm u) - f(x)|\, du = o\left[\frac{\lambda(1/t)\, t}{P_\tau}\right],$$

where $\lambda(t)$ be a positive, monotonic increasing function of t, and

$$\lambda(n) \log n = O(P_n), \text{ as } n \to \infty,$$

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then the Legendre series is summable (N, p_n) to $f(x)$ at an internal point x of the interval $(-1+\epsilon, 1-\epsilon)$, $\epsilon > 0$ where $\{p_n\}$ is a real non-negative and monotonic non-increasing sequence such that $P_n \to \infty$, as $n \to \infty$.

In Chapter V, we have established a theorem for the Nörlund summability of a double Fourier series, which is a generalization of the well known result of Pati [1] (1961) in two ways. More precisely we prove the following theorem :

If (N, p_m, q_n) be a regular duble Nörlund method, defined by real, non-negative, non-increasing sequences $\{p_m\}$ and $\{q_n\}$, such that $P_m \to \infty$ and $Q_n \to \infty$, as m, $n \to \infty$, then, if

$$\Phi(x, y) \equiv \int_0^x ds \int_0^y |\phi(s, t)| dt$$

$$= O\left[\frac{\alpha(1/x)\, x}{P_{[1/x]}} \cdot \frac{\beta(1/y)\, y}{Q_{[1/y]}}\right]$$

where $\alpha(x)$ and $\beta(y)$ are two positive monotonic increasing functions, with

(i) $\alpha(m) \log m = O(P_m)$ as $m \to \infty$,

(ii) $\beta(n) \log n = O(Q_n)$ as $n \to \infty$,

then, the double Fourier series of the function $f(x, y)$ is summable (N, p_m, q_n) to the sum at $x = u$ and $y = v$.

In 1962, Sahney [3], established a theorem for the Borel summability of derived Fourier series in the following form :

If

$$\int_0^t |\psi(u)| du = o\left(t/\log \frac{1}{t}\right)$$

then, the derived Fourier series is summable (B) to the sum zero at the point $t = 0$, where

$$\psi(t) = \tfrac{1}{2}\{f(x+t) - f(x-t)\}.$$

In Chapter VI, we have generalized the above theorem for the Borel summability of Legendre series in the following form :

If

$$\int_0^t |f(x \pm u) - f(x)| du = o(t/P_\tau), \text{ as } t \to 0,$$

and

$$\log(r^{1-\alpha}) = O(P_r), \text{ as } r \to \infty, \left(0 < \alpha < \tfrac{1}{2}\right),$$

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then the Legendre series is summable (B) to f (x) at an internal point x of the interval $(-1, +1)$, where $\{p_n\}$ is real non-negative and monotonic non-increasing sequence of constants such that

$$\sum_{\gamma=0}^{n} p_\gamma = p_n \to \infty \text{ as } n \to \infty.$$

In 1980, Prasad [2] has proved a theorem for the Strong Matrix summability of ultra-spherical series in the following form :

Let $\phi(\omega) \in BV(\eta, \pi)$, where $\eta = \frac{\mu}{n^\Delta}$, $\frac{1-\lambda}{\lambda} > \Delta > 0$, $0 < \lambda < 1$;

and μ is large constant.

If

$$\Phi(t) \equiv \int_0^t |\phi(\omega)| \, d\omega = O(t^\alpha / (\log \frac{1}{t})^{1+\epsilon}), \epsilon > 0,$$

where $\alpha = \frac{2\lambda + 1 - \Delta}{\Delta}$, as $t \to 0$, then the Ultra-spherical series is summable $[\Lambda]$ with index $q(q>0)$ to the value A, where A is fixed constant, provided that $[\Lambda]$ is regular.

In the last chapter, we have generalized the above theorem for the strong Matrix summability of ultra-spherical series. We prove the following theorem [6].

Let $\phi(\omega) \in BV(\eta, \pi)$, where $\eta = \frac{\mu}{n^\Delta}$, $\frac{1-\lambda}{\lambda} > \Delta > 0$, $0 < \lambda < 1$, and μ is large constant.

Let $\{q_n\}$ be a real non-negative monotonic non-increasing sequence of constants such that $\sum_{\gamma=0}^{n} q_\gamma = Q_n \to \infty$ as $n \to \infty$.

If

$$\Phi(t) \equiv \int_0^t |\phi(\omega)| \, d\omega = O\left[\frac{t^\alpha}{(Q_\tau)^{1+\epsilon}}\right], \epsilon > 0$$

$\tau = [1/t]$ denoting the integral part of $1/t$, where $\alpha = \frac{2+1-\Delta}{\Delta}$, as $t \to 0$, then the Ultra-spherical series is summable $[\Lambda]$ with index q $(q>0)$ to the value A, A being a fixed constant, provided that $[\Lambda]$ is regular.

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A STUDY ON A MODIFIED H-FUNCTION OF TWO VARIABLES AND ITS APPLICATIONS

Prem Shanker Singh Sup. : *Dr, Y. N. Prasad*

The thesis comprises of six chapters. In introductory chapter, the author adheres to the compendious and upto-date survey of the results presented by various researchers in this field and their connections to the present work, the modified H-function of two variables under our present study has been defined and represented as follows :

$$H[x,y] = H\begin{matrix} m_1,n_1; m_2,n_2 : (m_3,n_3); (m_4,n_4) \\ p_1,q_1; p_2,q_2 : [p_3,q_3]; [p_4,q_4] \end{matrix}\left[\begin{matrix} \{(a_{p_1}; \alpha_{p_1}, A_{p_1})\}; \\ \{(b_{q_1}; \beta_{q_1}, B_{q_1})\}; \end{matrix}\right.$$

$$\left.\begin{matrix} \{(c_{p_2}; \gamma_{p_2}, C_{p_2})\} : (e_{p_3}, E_{p_3})\}; (g_{p_4}, G_{p_4})\} \\ \{(d_{q_2}; \delta_{q_2}, D_{q_2})\} : \{(f_{q_3}, F_{q_3})\}; \{(h_{q_4}, H_{q_4})\} \end{matrix}\right| \begin{matrix} x \\ y \end{matrix}\Bigg]$$

$$= \frac{1}{(2\pi i)^2}\int_{L_1}\int_{L_2} \phi(s,t)\ \theta_1(s)\ \theta_2(t)\ x^s\ y^t\ ds\ dt,$$

$$\phi(s,t) = \frac{\prod_{j=1}^{m_1}\Gamma(b_j - \beta_j s - B_j t)\prod_{j=1}^{n_1}\Gamma(1-a_j+\alpha_j s+A_j t)}{\prod_{j=m_1+1}^{q_1}\Gamma(1-b_j+\beta_j s+B_j t)\prod_{j=n_1+1}^{p_1}\Gamma(a_j-\alpha_j s-A_j t)}$$

$$\frac{\prod_{j=1}^{m_2}\Gamma(d_j-\delta_j s+D_j t)\prod_{j=1}^{n_2}\Gamma(1-c_j+\gamma_j s-C_j t)}{\prod_{j=m_2+1}^{q_1}\Gamma(1-d_j+\delta_j s-D_j t)\prod_{j=n_2+1}^{p_2}\Gamma(c_j-\gamma_j s+C_j t)}$$

$$\theta_1(s) = \frac{\prod_{j=1}^{m_3}\Gamma(f_j - F_j s)\prod_{j=1}^{n_3}\Gamma(1-e_j+E_j s)}{\prod_{j=m_3+1}^{q_3}\Gamma(1-f_j+F_j s)\prod_{j=n_3+1}^{p_3}\Gamma(e_j-E_j s)}$$

$$\theta_2(r) = \frac{\prod_{j=1}^{m_4}\Gamma(h_j - H_j t)\prod_{j=1}^{n_4}\Gamma(1-g_j+G_j t)}{\prod_{j=m_4+1}^{q_4}\Gamma(1-h_j+H_j t)\prod_{j=n_4+1}^{p_4}\Gamma(g_j-G_j t)}$$

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where x and y are not zero and an empty product is interpreted as unity. Also m_1, m_2, m_3, m_4; n_1, n_2, n_3, n_4; p_1, p_2, p_3, p_4; q_1, q_2, q_3, q_4 all are positive integers such that $1 \leqslant m_i \leqslant q_1$ $(i = 1,2,3,4)$, $1 \leqslant ni \leqslant p_i$ $(i = 1,2,3,4)$, the letters $\alpha, \beta, \gamma, \delta$, A, B, C, D, E, F, G, H (with suffixes) are all positive numbers and each of the letters a, b, c, d, e, f, g, h (with suffixes) are complex numbers. The contour L_1 and L_2 respectively of the S - and t - planes, do not intersect any singularities of the integrand. The function defined above is an analytic function of x and y, if

$$R = \sum_{j=1}^{p_1} \alpha_j + \sum_{j=1}^{p_2} \gamma_j + \sum_{j=1}^{p_3} E_j - \sum_{j=1}^{q_1} \beta_j - \sum_{j=1}^{q_2} \delta_j - \sum_{j=1}^{q_3} F_j < 0,$$

$$S = \sum_{j=1}^{p_1} A_j + \sum_{j=1}^{p_2} D_j + \sum_{j=1}^{p_4} G_j - \sum_{j=1}^{q_1} B_j - \sum_{j=1}^{q_2} C_j - \sum_{j=1}^{q_4} H_j < 0,$$

and the above integral converges under the following set of conditions :

$|\arg x| < \frac{1}{2} U \pi$, $|\arg y| < \frac{1}{2} V \pi$

$$U = \sum_{j=1}^{n_1} \alpha_j - \sum_{j=n_1+1}^{p_1} \alpha_j + \sum_{j=1}^{m_1} \beta_j - \sum_{j=m_1+1}^{q_1} \beta_j + \sum_{j=1}^{n_2} \gamma_j - \sum_{j=n_2+1}^{p_2} \gamma_j + \sum_{j=1}^{m_2} \delta_j$$

$$- \sum_{j=m_2+1}^{n_2} \delta_j + \sum_{j=1}^{n_3} E_j - \sum_{j=n_3+1}^{p_3} E_j + \sum_{j=1}^{m_4} F_j - \sum_{j=m_4+1}^{q_4} F_j > 0,$$

$$V = \sum_{j=1}^{n_1} A_j - \sum_{j=n_1+1}^{p_1} A_j + \sum_{j=1}^{m_1} B_j - \sum_{j=m_1+1}^{q_1} B_j + \sum_{j=1}^{n_2} C_j - \sum_{j=n_2+1}^{p_2} C_j + \sum_{j=1}^{m_2} D_j$$

$$- \sum_{j=m_2+1}^{q_2} D_j + \sum_{j=1}^{n_4} G_j - \sum_{j=n_4+1}^{p_4} G_j + \sum_{j=1}^{m_4} H_j - \sum_{j=m_4+1}^{q_4} H_j > 0,$$

For $m_1 = m_2 = n_1 = n_2 = 0$, we have denoted the modified H - function by *H [x, y]. By considering the behaviour of Gamma functions involved in *H [x, y] it can be shown to be of algebraic order

$$*H[x, y] = 0(|x|^{\alpha'} |y|^{\beta'}),$$ for small values of x and y,

$$*H[x, y] = 0(|x|^{\gamma'} |y|^{\delta'}),$$ for large values of x and y,

where

$$\alpha' = \min \operatorname{Re}(f_j/F_j),\ j = 1, 2, \ldots, m_3$$

$$\beta' = \min \operatorname{Re}(h_j/H_j),\ j = 1, 2, \ldots m_4,$$

$$\gamma' = \max \operatorname{Re}\left(\frac{e_j - 1}{E_j}\right),\ j = 1, 2, \ldots, n_3,$$

$$\delta' = \max \operatorname{Re}\left(\frac{g_j - 1}{G_j}\right),\ j = 1, 2, \ldots, n_4$$

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when $m_1 = m_2 = n_1 = n_2 = p_2 = q_2 = 0$, we have denoted the modified H-function of two variables by $^{**}H[x, y]$ which is the same as H-function of two variables by P. K. Mittal and K. C. Gupta.

In Chapter II we have discussed the finite and infinite integrals involving the product of the modified H-function of two variables. On account of the general nature of our modified H-function, the results of this Chapter will serve as rich sources of known and unknown results for many special functions.

Chapter III deals with double Laplace transforms and identities involving the modified H-function of two variables. Some interesting known and unknown results are also discussed.

Chapter IV deals with fractional operations involving the modified H-function of two variables With the help of these operators we have discussed eight theorems which are rich sources of known and unknown results for many special functions.

Chapter V introduces a generalized *P-polynomial in terms of Fox's H-function with the modified H-function of two variables as a generating relation. This generalized *P-polynomial is defined and represented as :

$$H_{\substack{o,o;\ o,o:(m_1+1,\ n_1);\ (m_2+1,\ n_2+1) \\ o,o;\ 1,o:]p_1,\ q_1+1];\ [p_1+1,\ q_1+1]}}\left[\begin{matrix} -\ ;\ (1,1,1):\ \{(a_{p_1}, A_{p_1})\}\ ; \\ -\ ;\ ---:\ (o,1),\ \{(b_{q_1}, B_{q_1})\}\ ; \end{matrix}\right.$$

$$\left.\begin{matrix} (o,1),\ \{(e_{p_2}, E_{p_2})\} \\ (o,1),\ \{(f_{q_2}, F_{q_2})\} \end{matrix}\right|\begin{matrix} x \\ -y \end{matrix}\Bigg]$$

$$= \sum_{n=o}^{\infty} {}^{*}P_n(x)\, y^n,$$

for all finite x and y, where $|\arg x| < \frac{1}{2} U\pi$, $U > 0$, $|\arg(-y)| < \frac{1}{2} VII$, $V > 0$,

$$U = \sum_{j=1}^{m_1} B_j - \sum_{j=m_1+1}^{q_1} B_j + \sum_{j=1}^{n_1} A_j - \sum_{j=m_1+1}^{p_1} A_j$$

$$V = 1 + \sum_{j=1}^{m_2} F_j - \sum_{j=m_2+1}^{q_2} F_j + \sum_{j=1}^{n_2} E_j - \sum_{j=n_2+1}^{p_2} E_j,$$

$m_1, m_2, n_1, n_2, p_1, p_2, q_1, q_2$ are all positive integers ; a, b, e, f are all complex numbers (with suffixes) ; A, B, E, F (with suffixes) are all positive numbers, and

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$$*p_n(x) = \frac{\prod_{j=1}^{m_2} \Gamma(f_j - F_j n) \prod_{j=1}^{n_2} \Gamma(1 - e_j + E_j n)}{\prod_{j=m_2+1}^{q_2} \Gamma(1 - f_j + F_j n) \prod_{j=n_2+1}^{p_2} \Gamma(e_j - E_j n)} \times H^{m_1+1, n_1}_{p_1+1, q_1+1}\left[x \middle| \begin{matrix} \{(a_{p_1}, A_{p_1})\}, (n+1, 1) \\ (o, 1), \{(b_{q_1}, B_{q_1})\} \end{matrix} \right]$$

It is easy as well as important to observe that the generalized *P polynomial may, in a obvious manner, be reduced to the Laguerre, Hermite, Legendre Jacobi, Gegenbauer, Ultraspherical Bateman, Rice's polynomials etc.

The author has further established two generating relations, three recurrence relations, expansions of the generalized *P-polynomial in terms of well known polynomials and vice versa, integrals and series relations for the generalized *P-polynomial. Many known and unknown results have also been discussed.

Chapter VI has been devoted to some applications of the modified H-function of two variables. Here, the author has chosen only two avenues of applications which are :

(j) The modified H-function of two variables as an application to the vibrations of a circular membrane.

(ii) Application of the modified H-function of two variables in vibrations of a rectangular membrane.

SOME LOCAL AND COSMOLOGICAL SOLUTIONS OF CYLINDRICAL SYMMETRY IN GENERAL RELATIVITY

Shyam Narain Sup. : *Dr. S. R. Roy*

The thesis entitled "Some local and cosmological solutions of cylindrical symmetry in general relativity" comprises five chapters. The first chapter is introductory which contains well known results concerning certain material distribution and space-time symmetries. These include perfect fluid, dust, stiff fluid, disordered radiation, electromagnetic field and scalar meson field and certain space- time symmetries including spatially homogeneous space-times, plane—symmetric, spherically symmetric and cylindrically symmetric space-times and Petrov—classification.

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The Chapters I to V consist of our original work. In all these chapters the metric considered is due to Marder (1958) viz.

(1) $ds^2 = A^2 (dt^2 - dx^2) - B^2 dy^2 - C^2 dz^2$

and the Einstein's field equations have been solved for different type of material distribution under different physical and geometrical conditions and conditions on the metric potentials. Some simple physical and geometrical properties of the models have been examined.

In the second Chapter Einstein's equations have been solved for the metric (1) where the metric potentials are function of x and t both. The distribution filling the space-time is of perfect fluid which is assumed to satisfy the equation of state $\rho = p$. Six models have been obtained of which only four are realistic and their Petrov-types have been examined.

There are two sections in Chapter III. In the first section Einstein's field equations for perfect fluid distribution have been solved for the metric (1) taking the metric potentials to be functions of x and t. The space-time is assumed to be of Petrov-type D satisfying one of the type D conditions viz.

(2) $C_{(1212)} = C_{(1313)}$ and $C_{(1224)} = 0$

and we have obtained three realistic metrics which turn out to be Robertson-Walker space-time. In this section we have summarised the result as follows, "Every time dependent cylindrically symmetric metric, representing perfect fluid distribution and satisfying type D condition (2) is always a Robertson-Walker metric. In the second section of this chapter Einstein's equations have been solved for metric (1) with metric potentials $A = 1$ for perfect fluid distribution. A particular form of the metric obtained is of Petrov-type II which exhibits gravitational radiation.

In the fourth Chapter Einstein's equations have been solved for metric (1) with perfect fluid distribution and the metric potentials are taken to be functions of x and t. Six realistic models have been obtained assuming different simple functinal forms for the metric potentials. Of these models one is an inhomogeneous generalisation of Bianchi-type I model, another is inhomogeneous generalisation of Bianchi-type VI_0 and the remaining four are inhomogeneous generalisation of Bianchi-type V universe. An interesting property of the model generalising Bianchi – type VI_0 space-time is that it tends to homogeneity for large values of time.

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There are two sections in the fifth Chapter. In the first section Einstein's field equations have been solved for metric (1) where the distribution is of perfect fluid with incident magnetic field. The metric potentisls are assumed to be inter-related by $A = BC$ and having particular functional form. Five models have been derived of which three are Bianchi-type VI_0 and remaining two are static models. In the second section of this chapter metric potentials are taken as function of time alone having the relation $A = B^m C^n$ which is a generalisation of the case considered by Tiwari (1980).

A FUNCTIONAL ANALYTIC INVESTIGATION OF THE KOLMOGOROV SUPERPOSITION THEOREM

Shantanu Bhattacharya Sup.: *Dr. V. L. N. Sarma*

In an attempt to apply methods of nomography to the solution of algebraic equations of the 7-th degree, David Hilbert came across the problem :

Whether all continuous real functions of k ($\geqslant 2$) real variables can be expressed in terms of continuous real functions of one variable and addition, using only a finite number of superpositions and addition. 'Superposition', in this context, means composition of functions.

This problem came to be known as Hilbert's thirteenth problem (cf. [5]).

Though the problem was under the active attention of mathematicians from 1900 on, it was not till 1957 that definite solutions were published by Arnol'd [1] and his teacher, Kolmogorov [3]. As reformulated and simplified by Sprecher [7] and Lorentz [4], the theorem states :

Given a positive integer k ($\geqslant 2$) and rationally independent real numbers $\alpha_1, \ldots, \alpha_k$ in (0, 1], there exist $2k+1$ strictly increasing maps $\phi_1, \ldots, \phi_{2k+1}$ of the unit interval [0, 1] into itself, such that, the following assertion is true :

For any real continuous function f of k variables, $0 \leqslant x_p \leqslant 1$, $p = 1, \ldots, k$, there corresponds at least one real continuous function g on [0, k] such that

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$$f(x_1, \ldots, x_k) = \sum_{q=1}^{2k+1} g\left(\sum_{p=1}^{k} \alpha_p \phi_q(x_p)\right),$$

$$(x_1, \ldots, x_k) \in [0, 1]^k;$$

and $\|g\|_\infty \leqslant M \|f\|_\infty$ for some $M > 0$.

The usual proofs of this theorem proceed by actually constructing the ϕ_q's and then g. The only exception, as far as we know, is Kahane's proof [2] which uses category arguments. Constructive proofs have all the logical and psychological advantages claimed for them, but quite often they fail to put a mathematical result in its proper setting. This is what we attempt to remedy by trying to work out an independent functional analytic proof of the Kolmogorov Theorem.

After first making a change of variables and restricting attention to real analytic functions (instead of all continuous functions) of k-variables (which can be identified with the Banach spaoe of k-fold sequences of real numbers, converging absolutely - $l_1^{(k)}$), we look for a linear, bounded (with $l_1^{(k)}$ norm) transformation T (Kolmogorov transformation) from $l_1^{(k)}$ to the space of continuous functions of one variable, such that T f acts as g in the theorem, f in $l_1^{(k)}$.

Initially we allow the number of functions $\phi_1, \phi_2, \ldots\ldots$ to be an unspecified N. We assume nothing more than continuity for $\phi_1, \ldots \phi_N$, and the numbers $\alpha_1, \ldots, \alpha_k$ only belonging in (0, 1]. We allow later theory to dictate whetever restrictions are needed on the number N and on the the nature of $\phi_1, \ldots, \phi_N$; $\alpha_1, \ldots, \alpha_k$.

If T is arbitary, we need not expect

$$f(x_1, \ldots, x_k) - \sum_{q=1}^{N} (T f)\left(\sum_{p=1}^{k} \alpha_p \phi_q(x_p)\right), \quad f \in l_1^{(k)},$$

to vanish. "We treat this as a random variable on the probability space $I^k \times S_\infty$, where $I = [-1, 1]$, and S_∞ the clossed unit ball in $l_1^{(k)}$". I^k carries the (normalized) k – dimensional Lebesgue measure and S_∞ carries the Eberlein measure [6]. Denoting the variance of our random variable by $\sigma^2(T)$, we seek to minimize $\sigma^2(T)$ as a function of T. Our problem then becomes a minimization problem, and we approach it in a functional analytic setting.

We first derive a criterion for inf σ^2 (T) to be zero, in terms of the functions ϕ_q and the constants α_p, which takes the form that the sequence

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$$\left\{ \sum_{q=1}^{N} \left(\sum_{p=1}^{k} a_p \phi_q (x_p) \right)^n : n = 0, 1, 2, \ldots \right\}$$

be fundamental in $L^2 (I^k, m)$,

and then several other equivalent formulations.

We then present the problem of locating T, such that $\sigma^2(T) = 0$, as a moment problem.

A conclusive proof that T exists with $\sigma^2 (T) = 0$ is not claimed (though it is shown that using Kolmogorov's theorem, such T exists).

FINITE HANKEL TRANSFORMATIONS OF DISTRIBUTIONS

Om Prakash Singh Sup. : *Dr. R. S. Pathak*

In Chapter I, we have obtained a representation for the generalized finite Hankel transform of a class of generalized functions as a continuous function of slow growth. More precisely, it has been shown that with certain restrictions, the generalized finite Hankel transform F(y) under consideration is given by

$$F(y) = \sum_{i=o}^{r} (-1)^{i+r} a_i (\mu)\, y^i\, G_{i-r}^{i+\mu} (y),$$

where $a_i (\mu)$ is a constant and $G_{i-r}^{i+\mu} (y)$ is a bounded continuous function, defined for $0 < y < \infty$, for each i.

An alternative structure formula has been also obtained as follows :

$$F(y) = \langle D^r h(x),\ \lambda_\epsilon (x) \sqrt{xy}\, J_\mu (xy) \rangle.$$

In Chapter II, we analyse further the generalized finite Hankel transform defined in Chapter I. We obtain integral representation for the members of the testing function space, which in turn gives the structure formula for F(y) in a more general setting.

We also extend generalized function of our generalized function space periodically on a larger testing function space.

Further, it is shown that the generalized finite Hankel transform F is the limit, as $\epsilon \to 0+$, of a certain family $F_\epsilon (Z)$ of regular generalized functions belonging to the same space as of F.

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Finally, we have obtained a Fourier-Bessel representation for the generalized functions.

In Chapter III a Dini series representation of some generalized functions has been investigated. To be more specific, finite Hankel transform of second kind of certain generalized functions has been defined and an inversion theorem, as an extension to generalized functions of a classical inversion formula [28, p. 101] has been proved. An operational transform formula has also been obtained and applied in solving a distributional differential equation.

In Chapter IV, finite Hankel transform of third kind of certain generalized functions has been defined (on the pattern of Chapter III) and an inversion theorem, as an extension to generalized functions of a classical inversion formula has been proved. An operational transform formula has also been defined and applied in solving a distributional differential equation.

GEOMETRICAL CHARACTERIZATIONS AND SOLUTIONS IN MAGNETOFLUID FLOWS

Shesh Nath Singh Sup. : *Dr. Ram Babu Mishra*

The thesis consists of five chapters and each chapter is subdivided into sections.

Chapter I is introductory. It contains the general history of magnetofluid dynamics, basic equations governing MFD and dusty gas flows, definitions of some special flows, description of curves and surfaces associated with the geometry of flows, geometry of vector lines and vector tubes, review of geometrical work of MFD and perfectly conducting dusty gas flows and some results from the differential geometry which are relevant to the development of present work.

Chapter II presents the intrinsic description of magnetic vector field and vortex vector field. The whole chapter is divided into two parts. Part I deals with the geometry of magnetic field lines in MFD flows. Decomposing along the magnetic field line triad it is shown that the family of Maxwellian surfaces is a normal congruence of developable surfaces under certain conditions. In part II the

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geometry of vortex line triad is discussed for steady, rotating MFD flows. The complex lamellar motion is also discussed. The necessary and sufficient condition for the Maxwellian surfaces to be minimal surfaces has been obtained, and it is shown that under what conditions the vortex-lines lie on the Bernoulli surface.

In Chapter III, constantly inclined viscous incompressible plane flows are considered. The geometries of an irrotational flow with constant velocity magnitude along each stream line are studied. The uniqueness property and solution for vortex flow and straight parallel flow are obtained for viscous incompressible fluids, when the magnetic field and velocity field are constantly inclined.

In Chapter IV, the basic equations of MGD flow of a dusty gas are reformulated in terms of curvilinear coordinates. The family of Maxwellian surfaces is considered as one of the families of coordinate surfaces. The stream lines and magnetic field lines are treated as the coordinate curves. Using this new system of basic equations the transverse flow is studied for the variable dust particle distribution function. It is shown that under what conditions the Maxwellian surfaces are developables.

In the last Chapter, plane transverse flow of a dusty gas is considered. It has been divided into two parts. Part I deals with the incompressible and viscous flow. It is shown that the only possible flow is flow in parallel straight lines or radial flow when the velocities of dust and gas are everywhere parallel. The admissible flow geometries of straight parallel flow and radial flow are obtained for some special values of the particle number density It is shown that when number particle density is constant, there exists no plane radial flow. In part II the effects of compressibility and viscosity are included. Solutions for straight parallel flows and radial flows are obtained by imposing restrictions on one or more functions of gas velocity, gas density and number particle density.

We have confined ourselves to the study of geometrical aspects of flows and in few chapters we have obtained some solutions of physical importance. The conditions of continuity and differentiability of functions, if required, are assumed to be satisfied.

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ON A POLYNOMIAL SET AND ITS EXTENSIONS

Priti Pandey Sup. : *Dr. I. K. Khanna*

The present thesis entitled, "On a polynomial set and its extensions (special functions of complex analysis)", comprises six chapters.

Chapter I consists of mainly a brief historical account of unifications of classical as well as non-classical polynomials given by defferent authors. Unifications and extensions of special functions and polynomials have been arrived at, by considering different ways of defining them, such as by means of Generating relations, Rodrigues formulae, Differential equations, Recurrence relations etc. I have arranged different unifications and generalizations given by different researchers chronologically. Due to the lack of the space, it was not possible to give all of the generalizations. For more detail, one is referred to the list of the references given at the end. Further, the definitions of symbolic relation, Laplace transformation and the Jannery's theorem are also given. The chapter is concluded by giving some notations and one lemma which are used throughout the thesis frequently.

Chapter II introduces the polynomial set $P_n^{(\alpha, \beta)}(x, y ; a, k)$ which unifies a set of seven polynomials and numbers like Bernoulli, Euler, Eulerian etc. After having defined the polynomial set $P_n^{(\alpha, \beta)}(x, y ; a, k)$, the following properties have also been obtained :

1. Series form.
2. Conditions for the existence for the polynomial set.
3. Different hypergeometric forms.
4. Recurrence relations which include differential recurrence relations, mixed recurrence relations and a contiguous recurrence relation.
5. Some interesting formulae.

This Chapter is concluded by giving some hypergeometric forms for the particular case $a = 0$.

There are two sections in Chapter III. Section one starts with the expansion theorem of x^n in terms of $P_n^{(\alpha, \beta)}(x, y ; a, k)$, which is followed by some reversible expansion formulae between the polynomial set $P_n^{(\alpha, \beta)}(x, y ; a, k)$ and classical polynomials like Hermite, Laguerre, Legendre.

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Expansion of y^n in terms of the polynomial $P_n^{(\alpha, \beta)}(x, y ; a, k)$ is given in section two. Further, reversible expansion formulae for Sister Celine polynomials and $P_n^{(\alpha, \beta)}(x, y ; a, k)$ are derived. Finally, this section is concluded by giving expansion of Hermite polynomials in terms of $P_n^{(\alpha, \beta)}(x, y ; a, k)$ and vice-versa.

Chapter IV deals with integral representations of the polynomial set $P_n^{(\alpha, \beta)}(x, y ; a, k)$. The following five different types of integral representations have been obtained :—

1. Contour integral representations,
2. Infinite double integral representations,
3. Finite double integral representations,
4. Infinite single integral representations,
5. Finite single integral representations.

Further, Laplace transformations for the polynomial set $P_n^{(\alpha, \beta)}(x, y ; a, k)$ are given. The chapter is concluded by giving a corollary in which, a property of the Laplace transformation is derived for the polynomial set.

Chapter V comprises two sections. In the first section, certain important properties for the polynomial set $P_n^{(\alpha, \beta)}(x,y;a,k)$. have been obtained. These are :

1. Characterization.
2. n^{th} differential formulae.
3. Asymptotic behaviour for large values of n.
4. Another generating relation.
5. Differential equation for $P_n(x, y ; 0)$.

At the end of the section, a formula has been derived, which shows that $P_{k+2}(x, y ; 0)$ is one of the solutions of the wave equation.

In the second section, an attempt has been made to extend the Bernoulli and Genocchi numbers in a different way. After defining the sequence of numbers $\left\{ P_{n; k}^{(a,\beta)} \right\}$, some particular values of $P_{n; k}^{(a,\beta)}$ for $n=0, 1, 2, \ldots$ are obtained. It is followed by the general expressions for $P_{n; k,}^{(a,-1)}$ $P_{n; k}^{(a,-2)}$. The section is concluded by giving some applications of the numbers.

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In Chapter VI, an attempt has been made to extend the polynomial set $P_n^{(\alpha,\beta)}(x,y;a,k)$ in two different ways.

In section one, the first extension $(Q_n(x, y, z)$ of $P_n^{(\alpha,\beta)}(x, y; a, k)$ is discussed. This is a polynomial of three variables and it unifies eight polynomials like Bernoulli, Karande and Thakare etc. After defining the polynomial set $Q_n(x, y, z)$, (1) Series forms, (2) conditions for the existence of $Q_n(x, y, z)$, (3) particular cases of $Q_n(x, y, z)$, (4) recurrence relations, (5) asymptotic expansion, (6) Laplace transformations, (7) Integral forms of different types, (8) an additional theorem have been obtained. The section is concluded by deriving some interesting properties for $Q_n(x, y, z)$.

In second section, another extension of $P_n^{(\alpha,\beta)}(x, y; a, k)$ is given. This is a polynomial of four variables and unifies eleven polynomials and numbers. Further particular cases, recurrence relations, integral representations have been derived. The section is concluded by introducing some interesting formulae.

A GENERALIZED APPELL-FUNCTION OF TWO VARIABLES AND THE POLYNOMIALS

Shri Kant Sup. : *Dr. R. N. Pandey*

The subject "Special function" has been studied since long, but a systematic study of the subject has been done during the last three decades only. This subject is in continual demand by scientists and engineers because a great variety of functions and higher accuracy of tabulation are now required as a result of technical advances and especially of the increasing use of high speed computers. The main aim of the present thesis is unification of orthogonal and non-orthogonal polynomials.

The thesis consists of five chapters.

Chapter I comprises mainly a historical account of different unifications of orthogonal and non-orthogonal polynomials and generalization associated with them by a number of authors. At the end of the chapter notations and lemmas, have been given which are of extensive use.

Chapter II, is concerned with the study of a generalized polynomial set $\{A^*_{\alpha_2 n}(x,y)\}$ which has been defined by means of a

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generating function containing Appell double hypergeometric function of two variables in the notation of Burchnall and Chaundy. The polynomial set yields as particular cases a number of orthogonal and non-orthogonal polynomials such as Hermite, Rice, Gottlieb, Pasternack's polynomials etc., and discrete polynomials of Charlier and Meixner. These polynomials are of utmost importance for scientists and engineers, because these occur in the solutions of differential equations, Differential difference equation, Integrrodifferential equations, Integral equations etc., which describe physical problems.

This shows that the polynomial set $\{ A^*_{\alpha_2 n}(x,y) \}$ may be of immense use in further development of the subject.

Later in the chapter some hypergeometric forms of superior orders have been obtained in the form of corrollaries of the mein theorem and various known results have been worked out as particular cases of these corollaries. Generating functions for the some well known polynomials have also been obtained as particular cases. Finally, hypergeometric forms of superior orders have been obtained by imposing restrictions on the order of the polynomial set and also inverting the order of summations.

The Chapter III, deals with the expansions of the polynomial set in terms of finite series of Legendre, Sister Celine's polynomials and vice-versa. Particular cases of the general results have also been worked out. Further, the expansions of polynomial set has been obtained in a finite series of Bateman and Hermite polynomials.

Finally in this chapter some recurrence relations of pure and differential type followed by particular cases have been derived.

In Chapter IV, an attempt has been made to derive the differential equations for the polynomials $A^*_{\alpha_2 n}(x,y)$ with respect to x in terms of the operator, $\theta \equiv x\frac{\partial}{\partial x}$ and also with respect to y in terms of the operator, $\psi \equiv \frac{y}{c_2}\frac{\partial}{\partial y}$. The results thus obtained are given in the form of theorems. Complele solutions of these differential equations are also given. The verification of the solution for one particular case has been discussed in detail and it is found that one of the particular solutions is the polynomial set $\left\{ A^*_{\alpha_2 n}(x,y) \right\}$ itself and the rest particular solutions are functions. Some particular cases have been worked out. Further, the partial differential equations for the polynomial have been obtained in terms of the operators $\theta_1 \equiv \frac{y}{c'_2}\frac{\partial}{\partial y}$ and $\theta_2 \equiv \frac{x}{c_1}\frac{\partial}{\partial x}$ for different cases.

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Finally in this chapter, the polynomial set has been expressed in terms of nth derivatives of certain hypergeometric functions of superior orders. The results thus obtained have been given for particular set of values. A number of interesting results as particular cases of the general result have been deduced, out of which some of the results are believed to be new.

Chapter V, consists of two sections. In section 1, finite single, infinite single and a finite double integral representations for the polynomial set $\left\{ A^*_{\alpha_2 n}(x, y) \right\}$ have been worked out.

In section 2, the asymptotic behaviour of the generalized polynomial set (limit relations) when the order of the polynomial set n tends to infinity has been found. Finally the polynomial set has been expressed as limits when a parameter u tends to infinity in the hypergeometric functions, u being either in the set of parameters or in the argument.

All the results have been given in the form of theorems and various interesting results from the integral representations and asymptotic behaviour have been achieved, out of which some of the results may be considered to be new.

SOME RESULTS ON THE SUMMABILITY OF SERIES

Mithilesh Kumar Ojha Sup. : *Dr. L. M. Tripathi*

1. The present dissertation is an outcome of the investigations of the author into the theory and applications of ordinary and absolute summability of infinite series. It consists of eight chapters.

In Chapter I which is introductory an attempt has been made to present a brief account of the existing results which form a background for my investigations into the problems dealt with in the subsequent chapters of the thesis.

2. A brief summary of the problems studied and the results obtained in chapter II to VIII of this thesis, are now given.

The earliest investigations of the convergence of Legendre series was given by Dini [4] in 1875. It was further studied in more detail and systematic manner by Hobson [8] in 1909. In 1918, Haar [5] and [6] made a comparative study of the convergence of Legendre series

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with the Fourier series of function f(x) of class L^2. Young [23] also in 1919 gave a theorem on equi-convergence of Legendre series and Fourier series, which was based on restricted Fourier series.

Tripathi and Mishra [20] have established a theorem for the Uniform Nörlund summability of a Legendre series, in the following form :

Let $\epsilon(x)$ be a non-negative function of x such that $\epsilon(x)/(x \log x)$ is monotonic and $\epsilon(x)/\log x = O(1)$, as $x \to \infty$.

If

$$\sum_{\nu=2}^{n} \frac{\epsilon(\nu)\, Q_\nu}{\nu \log \nu} = O(Q_n), \text{ as } n \to \infty$$

and

$$\int_0^t |f(x \pm u) - f(x)|\, dx = o\left[\frac{t\,\epsilon\left(\frac{1}{t}\right)}{\log \frac{1}{t}}\right],$$

uniformly in a set, defined in the interval $(-1, 1)$, in which $f(x)$ is bounded as $t \to +0$, the Legendre series is summable (N, q_n) uniformly in E to the sum $f(x)$, where $\{q_n\}$ is a sequence of real, non-negative and non-increasing constants such that $Q_n \to \infty$ with n.

In Chapter II of the present thesis we have established a theorem for the Nörlund summability of a Legendre series, which is more a general result than that of Tripathi and Mishra [20]. More precisely we prove the following form :

If

$$\int_0^t |f(x \pm u) - f(x)|\, du = o\left[\frac{\lambda(1/t)\, p_\tau^\alpha}{\beta(p_\tau^\alpha)}\right], \text{ as } t \to 0,$$

where $\lambda(t)$ and $\beta(t)$ are two positive, monotonic, non-increasing functions and

$$\lambda(n)\, p_n^\alpha = O\left[\beta(p_n^\alpha)\right], \text{ as } n \to \infty$$

and $\{p_n^\alpha\}$ is a real, non-negative, monotonic non-increasing sequence of coefficients with $\alpha \geqslant 1$ such that $p_n^\alpha \to \infty$, as $n \to \infty$, then the Legendre series is summable (N, p_n^α) to $f(x)$.

In 1961, Pati [16] has proved the following theorem :

If (N, p_n) be regular Nörlund method, defined by a real, non-negative, monotonic non-increasing sequence of coefficients $\{p_n\}$ such that $p_n \to \infty$, and $\log n = O(p_n)$, as $n \to \infty$, then, if,

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$$\Phi(t) \equiv \int_0^t |\phi(u)|\, du = o\left[\frac{t}{P_\tau}\right], \text{ as } n \to +0,$$

then, the Fourier series of f (t), at t = x, is summable (N, p_n) to f (x).

In Chapter III we [13] have extended the theorem of Pati [16] in the following form :

If (N, p_m, q_n) be a regular double Nörlund method defined by a real, non-negative, monotonic non-increasing sequence of coefficients $\{p_m\}$ and $\{q_n\}$, such as that $p_m \to \infty$ and $Q_n \to \infty$, when

$$\log m = O(p_m), \text{ as } m \to \infty$$

and

$$\log n = O(Q_n), \text{ as } n \to \infty, \text{ if,}$$

$$\Phi(x, y) \equiv \int_0^x ds \int_0^y |\phi(s, t)|\, dt$$

$$= o\left[\frac{x}{P_{[1/x]}} \quad \frac{y}{Q_{[1/y]}}\right],$$

then the double Fourier series of the function f (x, y) is summable (N, p_m, qn) to the sum S at x = u and y = v.

Several results have been obtained for the Nörlund summability of a derived series of a Fourier series, but nothing seems to have been done so far in the direction of the study of derived series of a Fourier series by Uniform Nörlund summability method. In an attempt to make an advance in this direction in Chapter IV, we have established the following theorem :

If $\alpha(t)$ denotes a function of t, $\alpha(t)$ and $t/\alpha(t)$ increases monotonically with t, where

$$\log n = O\{\alpha(Q_n)\}, \text{ as } n \to \infty$$

and

$$G(t) \equiv \int_0^t |dg(u)| = o\left\{\frac{t}{\alpha(Q_\tau)}\right\}$$

uniformly in a set E, in which f' (x) is bounded, as $t \to +0$, then, the derived series of a Fourier series is summable (N, q_n) uniformly, in E to the sum f'(x). Concerning the $\left(N, \frac{1}{n+1}\right)$. C_1 summability of a sequence of Fourier coefficients, Varshney [21], in 1959, proved the following theorem :

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If

$$\Psi(t) \equiv \int_0^t |\psi(u)|\, du = o\left[\frac{1}{\log \frac{1}{t}}\right],$$

as $t \to 0$, then the sequence $\{n B_n(x)\}$ is summable $\left(N, \frac{1}{n+1}\right)$. C_1, to the value $\frac{L(x)}{\pi}$, where $L(x)$ being a constant and L depends on x.

In Chapter V of this thesis we have extended a theorem for (N, P_n). (C, 1) summability of Fourier coefficients, by replacing the particular sequence $\left\{\frac{1}{n+1}\right\}$ by a more general sequence $\{p_n\}$, and then we give a more general condition for the (N, p_n). (C, 1) summability of the sequence $\{n B_n(x)\}$. We prove the following theorem :

If

$$\Psi(t) \equiv \int_0^t |\psi(u)|\, du = o\left(\frac{t}{P_\tau}\right), \quad \text{as } t \to 0,$$

and

$\log n = O(P_n)$, as $n \to \infty$, then the sequence $\{n B_n(x)\}$ is summable (N, p_n). (C, 1), to the value $L(x)/\pi$, $L(x)$ being a constant, where L depends on x and $\{p_n\}$ is a real, non-negative, non-increasing sequence of constant such that

$$\sum_{\nu=0}^{n} p_\nu = P_\nu \to \infty, \text{ as } n \to \infty .$$

In 1967, Beohar [3] proved the $|C, \delta|$ - summability of Laplace series when $\delta > 1$. In the present Chapter VI we [14] have obtained a theorem for $|C\ 1|_k$- summability of Ultraspherical series defined on a sphere S in the form of the following theorem :

If $\phi(\omega)$ is of bounded variation in (η, π), where

$$\eta = \frac{\mu}{n^\Delta}, \quad \frac{1-\lambda}{\lambda} > \Delta > 0, \ 0 < \lambda < 1$$

μ is a large constant, and if

$$\Phi_1(t) \equiv \int_0^t |\phi(\omega)|\, d\omega = O\left\{\frac{t^\alpha}{(\log \frac{1}{t})^{1+\epsilon}}\right\} \quad \epsilon > 0$$

where

$$\alpha = \frac{2\lambda + 1 - \Delta}{\Delta}, \text{ as } t \to 0,$$

then the Ultraspherical series is summable $|C, 1|_k$.

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Borel summability, among others, has been discussed by Knopp [10] and Hardy [7] in a systematic manner. In 1958, Parameswaran [15] studied comparison between Cesaro and Borel method of summability. In 1961, Sahney [18] proved a result for the Borel summability of Fourier series and extended [19] the same to the case of derived Fourier series in 1962. Sahney's [19] theorem runs as follows :

If

$$\int_0^t |\psi(u)|\,du = o\left[\frac{t}{\log\frac{1}{t}}\right]$$

then the derived Fourier series summable (B) to the sum zero at the point $t = 0$, where

$$\Psi(t) = \tfrac{1}{2}\{f(x+t) - f(x-t)\}$$

Chapter VII presents an analogous result for the Borel summability of Jacobi series in the form of the following theorem :

If

$$\int_0^t |f(x \pm u) - f(x)|\,dx = o\left[\frac{t}{\log\frac{1}{t}\log\log\frac{1}{t}}\right],$$

as $t \to 0$, then the Jacobi series is summable (B) to $f(x)$ at an interior point x of the interval $(-1, 1)$.

The method K^λ were first introduced by Karamata (1935) [9]. Lototsky (1963) [12] reintroduced the special case $\lambda = 1$. Only after the paper of Agnew (1957) [1], an intensive study of those and similar methods took place.

Vuckovic [22] has established the following theorem on the summability of Fourier series by Karamata methods :

If

$$\phi(t) = o\left[\frac{t}{\log\frac{1}{t}}\right], \quad (t \to +0),$$

then the Fourier series is K^λ – summable at the point x to $f(x)$ for every $\lambda > 0$.

In the last Chapter VIII, we have generalized the above theorem in the following form ;

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Let $\{p_n\}$ be a non-increasing sequence of real constants such that

$$P_n \to \infty, \text{ as } n \to \infty,$$

where

$$P_n = \sum_{\nu=0}^{n} p_\nu .$$

If

$$\phi(t) = o\left[\frac{t}{P_\tau}\right], \ (t \to +0),$$

then the Fourier series is summable $K^\lambda(\lambda>0)$ to the sum $f(x)$ at the point $t = x$.

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PHYSICS

STRUCTURAL DISORDER AND SOLID STATE TRANSFORMATIONS IN SINGLE CRYSTALS OF ZnS, $Zn_XCd_{1-X}S$ AND $Zn_XMn_{1-X}S$

M. T. Sebastian Sup : *Dr. P. Krishna*

It is well known that ZnS crystallizes in two polymorphic forms—wurtzite (2H) with a hexagonal packing ABAB...and sphalerite (3C) with the cubic packing ABCABC...The two structures are related by a reversible phase transformation that occurs around 1020°C, the wurtzite form being the high-temperature modification. When single crystals of the wurtzite form grown at temperatures above 1020°C, are allowed to cool to room-temperature they become metastable and disorder sets in through the nucleation of stacking faults in the basal planes. X-ray diffraction reveals crystals in different stages of transformation ranging all the way from the perfect 2H structure to a heavily disordered 3C. In addition to such disordered structures one occasionally encounters long-period polytypes in which the faults occur periodically giving rise to additional X-ray diffraction spots corresponding to the new periodicity along *c*. The origin of such long-period structures has been attributed to the expansion of stacking faults around an axial screw-dislocation of large Burgers Vector.

The present investigation was undertaken with a view to determine (i) the nature of the stacking faults that occur during the 2H-3C transformation in ZnS, and (ii) the mechanism of the solid-state transformation in crystals which do not contain an axial screw dislocation. To do this, we have grown single crystals of ZnS from the vapour phase at temperatures above 1020°C and investigated the disorder present in them on cooling to the room-temperature. In addition crystals with nearly perfect 2H structure were annealed at different temperatures for different lengths of time in order to initiate solid-state transformations in them and then quenched in water to arrest the transformation at different stages. After each annealing run the structure of the crystal was re-examined by X-ray diffraction methods to note the changes that have occurred. The diffuse-intensities produced along certain reciprocal lattice rows parallel to c* have been measured using a single-crystal X-ray diffractometer. The study reveals the following results ;

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(i) Stacking faults present in the disordered 2H crystals of ZnS are predominantly deformation faults.

(ii) The 2H→3C transformation in ZnS occurs by the nonrandom insertion of deformation faults preferentially at two-layer spacings.

(iii) The resulting 3C structure is invariably heavily twinned.

Since the faults occur non-randomly in the course of a phase-transformation, it is found that the theories of X-ray scattering from one-dimensionally disordered close-packed structure (developed on the assumption of random faulting) do not apply except in the initial stage of transformation when the nucleation of faults is nearly random. In order to understand the diffraction effects from such structures it is necessary to modify the theory and consider a non-uniform probability-distribution for the occurrence of faults during the transformation.

We have also investigated disorder effects and solid state transformations in solid solutions of ZnS with small amounts of CdS and MnS. Single crystals of the type $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ have been grown for different values of x and investigated in a manner similar to that described above for pure ZnS. It is found that the addition of CdS stabilizes the 2H structure and disorder effects do not occur in crystals of $Zn_xCd_{1-x}S$ for $x < 0.94$. For crystals of $Zn_xMn_{1-x}S$ disorder effects were found to persist in the entire range from $x = 0.9$ to 1.0. Annealing experiments performed wifh single crystals of $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ have revealed a new solid-state transformation from the 2H to the 6H structure in these materials. The 6H structure appears to form as an intermediate state in the 2H-3C transformation in the solid solutions of $Zn_xMn_{1-x}S$ ($x > 0.9$) and $Zn_xCd_{1-x}S$ ($x > 0.95$). The 6H is a stable state in $Zn_xCd_{1-x}S$ for $0.93 < x < 0.95$.

We have investigated in detail the possible mechanism of the 2H to 6H transformation in these crystals by quenching them at different stages of the transformation and recording the diffuse intensity along the 10.L reciprocal lattice row on a single-crystal diffractometer. It is found that the models of non-random faulting developed by Pandey, Lele and Krishna to explain the 2H to 6H transformation in SiC are not applicable here and it is necessary to consider a more complicated distribution of the faultprobabilities for the random nucleation of a fault (α) and the periodic nucleation of a fault (β) have been developed in a manner similar to that employed by Lele and Pandey for the 3C-2H transformation in cobalt. The probability α represents the probability of formation of a fresh 6H nucleus in the 2H structure while β represents

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the probability of growth of the 6H nucleus already formed. It is shown that such a 2-parameter model with $\beta >> \alpha$ closely approximates the actual situation obtaining in these crystals.

The entire thesis is divided into eight chapters.

Chapter I describes briefly the crystallography of ZnS structures, the notations used to describe them, the type of faults that occur and the physical properties influenced by them. Chapter II gives the relevant background and theory for in terpreting X-ray diffraction patterns from faulted close packed structures.

Chapter III describes the X-ray characterization of as-grown and annealed crystals of ZnS obtained from the vapour phase at temperatures above 1020°C. A wide range of defect structures are observed, which on annealing at temperatures above 300°C undergo further structural transformations finally terminating in a heavily twinned 3C structure. This 3C structure transforms back to a disordered 2H structure on annealing at temperatures above 1050°C. Long period polytype structures occur occasionally among the as-grown crystals. These also transform to a twinned 3C structure on annealing. The transformations are not accompanied by any macroscopic kinds in the crystals and appear to take place not by the expansion of faults around a screw dislocation but by the non-random nucleation of faults.

Chapter IV describes our investigation of the 2H-3H transformation in ZnS and the nature of the stacking faults involved in it. The 2H-3H transformation can be effected by a non-random insertion of deformation, growth or layer displacement faults. The nature of the stacking faults involved in the transformation is determined by studying the broadening of X-ray diffraction maxima for the reflections with $H\text{-}K \neq 3n$ ($n = 0$ or any integer). The point intensity distribution along the 10.L reciprocal lattice rows were collected from several slightly transformed crystals in steps of $\Delta L = 0.01$ using a four circle single crystal diffractometer. Analysis of the experimentally observed intensity profile shows that a random distribution of deformation faults is present in the initial stages of the transformation. Subsequently, the transformation proceeds through a non-random insertion of deformation faults on alternate layers. In the beginning of the transformation the deformation faults nucleate randomly at different regions in the 2H crystal, giving rise to diffuse streaks parallel to c* along reciprocal lattice rows with $H\text{-}K \neq 3n$ and the cubic reflections develop soon afterwards. The experimentally observed and theoretically calculated intensity profiles for a random distribution

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of deformation faults are found to be in good agreement in the initial stages of transformation but not afterwards.

Chapter V describes the investigation of stacking faults present in the disordered twinned 3C structure obtained after annealing the 2H crystals. Since the 3C nuclei are distributed randomly in a 2H crystal undergoing transformation the resulting 3C structure ought to contain a random distribution of growth (or twin) faults. This has been verified by studying the broadening of X-ray diffraction maxima for reflections with $HK \neq 3n$. The point intensity distribution along the 10.L rows of several disordered 3C crystals obtained after solid state transformation was collected on a four circle single crystal diffractometer and compared with the theoretically calculated intensity profiles expected for a random distribution of twin faults in the cubic structure. There is a good agreement between the observed and calculated intensity profiles.

Chapter VI describes the growth perfection and annealing behaviour of $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ single crystals. The $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ crystals were grown for different values of x from the vapour phase at 1100°C in the presence of H_2S gas. Examination of the as-grown crystals revealed dendritic growth in $Zn_{0.95}Cd_{0.05}S$ with the axis of the dendrites parallel to [1010]. The dendrites show branching and rebranching to 60° angles in a plane parallel to (0001) and finally merge to form a platelet Our X-ray diffraction studies show that the $Zn_xCd_{1-x}S$ crystals have only a perfect 2H structure for $x<0.93$ and all polytypes and disordered structures occur only when $x\geqslant 0.94$. The $Zn_xMn_{1-x}S$ contain disordered structures and polytypes for $x>0.90$. Needleshaped $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ crystals were annealed in vacuum in the temperature range 300 to 1100°C. This had led to the discovery of a new 2H-6H solid state transformation in these crystals. This 6H structure is an intermediate state and transforms to 3C on further annealing for $Zn_xCd_{1-x}S$ ($x>0.95$) and $Zn_xMn_{1-x}S$ ($x>0.9$). The 6H is a stable state in $Zn_xCd_{1-x}S$ for $0.93<x<0.95$.

Chapter VII describes our investigation of the mechanism of the 2H-6H transformation in $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ crystals. The point intensity distribution along the 10.L row of several partially transformed crystals was collected on a four circle single crystal diffractometer. It is shown that the one-parameter model proposed by Pandey, Lele and Krishna to explain the 2H-6H transformation in SiC is not applicable to Zn_xCd_{1-x} and $Zn_xMn_{1-x}S$ crystals undergoing the transformation. A two-parameter model similar to that developed

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by Lele and Pandey for the 3C-2H transformation in cobalt has been developed for the 2H-6H transformation by two alternative mechanisms (i) the layer displacement mechanism and (ii) the deformation mechanism. It is found that the experimentally observed intensity profiles are in closer agreement with those calculated theoretically for the deformation mechanism with $\beta >> \alpha$. This means the probability (β) of faults nucleating at 3-layer separations is much greater than that of random nucleation (α) at larger separations.

Finally, in Chapter VIII we sum up the present position of our understanding of the defects and phase-transformations in the ZnS, $Zn_xCd_{1-x}S$ and $Zn_xMn_{1-x}S$ systems and indicate some problems that are yet to be resolved satisfactorily.

MAGNETIC FIELD EFFECTS IN SILICON UNIJUNCTION TRANSISTORS AND THEIR APPLICATIONS

Shanker Lal Agrawal Sup : *Dr. P. Ramaswamy*

After the discovery of Hall effect in 1879 by E. H. Hall, the semiconductor magnetic sensors have attained considerable importance in various applications like measurement of high currents, power meters, contactless switches, contactless volume controls, multipliers etc. In view of their increasing role in modern technological development, a large number of magnetodevices have been developed from the point of view of improved magnetosensitivity and immunity towards ambient temperature.

The present day electronics is entirely based on the integrated circuit technology and digital systems which has revolutionised the concept of transducer technology too. There are two basic requirements of the present day transducers : (i) Keeping in view, the already developed state of silicon IC technology, the transducer is preferred to be of silicon so that it can be integrated on the same chip alongwith other signal processing circuits. (ii) The information about the quantity to be measured should be in digital form, i.e. variable frequency or variable pulse width, so that it is adaptable to modern microprocessor based system.

These two criteria make the silicon negative resistance devices most suitable for sensor applications and control systems. In the class of switching devices, silicon unijunction transistor is attaining impor-

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tance as magnetic sensors due to its simple device geometry and large magnetosensitivity. This served as a stimulus to study the influence of magnetic field on the electrical properties of silicon unijunction transistor in the present dissertation. Moreover, the application potentiality of this device as a magnetic sensor has also been explored. The present study has been split up into six chapters for the convenience of systematic presentation.

Chapter I deals with the critical survey of the literature pertaining to the galvanomagnetic effects in semiconductors and semiconductor devices relevant to the present study. In the beginning some of the galvanomagnetic effects like Hall Effect have been briefly outlined along with their applications. Later on, magnetic field effects on various semiconductor devices like magnetodiodes, magnetotransistors etc. have been discussed in a concise form. Finally, the review of the present state of knowledge and the scope of work on UJT as a magnetic sensor has been presented.

Chapter II is devoted to the study of the effect of magnetic field on various static electrical parameters of unijunction transistor. After briefly describing the principle of operation of UJT, the theoretical analysis of magnetically induced changes in peak point voltage, valley point voltage and valley point current have been carried out. Bar type structure of the device has been considered for the sake of simplicity in the theoretical formulation. It has been shown that the magnetoresistance and magnetoconcentration effect play an insignificant role in the magnetic change of peak point voltage. Instead, the magnetic change in peak point voltage is mainly on account of the well known Hall effect. This proposed fact has been confirmed experimentally on an n-type silicon unijunction transistor through the study of the magnetic field, current and polarity dependence of the magnetic change in peak point voltage. Our model is easily extendable to high resistivity (nearly intrinsic) samples taking into account the recombination dependent Hall effect.

In order to explain the magnetically induced changes in valley point voltage and valley point current of unijunction transistor, the emitter-base 1 diode has been presumed to be as a long diode. The assumption is experimentally verified from the emitter-base 1 diode current-voltage characteristics. Thus the magnetic changes in these parameters can be attributed to the magnetodiode effect in the emitter-base 1 long diode. This theoretical proposition is well corroborated experimentally. Polarity effects on the magnetic changes of valley

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point voltage and current have been also observed experimentally which have been attributed to the difference in the recombination properties of the surfaces containing the emitter junction and the one opposite to it. For the experimental verification of this contention, the measurement of effective life time of minority carriers in the base region of UJT has also been carried out using the well known open circuit voltage decay method. It is thus concluded from the study of static parameters of UJT in magnetic field that this is a unique device exhibiting different magnetoeffects in various regions of its current-voltage characteristics curve.

The study of the influence of magnetic field on dynamic parameters, the negative resistance and inductance of unijunction transistor has been taken up in Chapter III. The recent work of Vikulin et al (1979), which presents a theoretical description of these parameters both in the drift and diffusion approximation, has been utilised to develop theoretical formulation of the magnetic changes in these parameters. The present analysis assumes the small signal and low frequency conditions. The influence of magnetic field on these parameters has been interpreted in terms of the changes in electrophysical parameters of the device, i. e. mobility of majority and minority carriers and effective life time of minority carriers. It is to be noted that both the drift and diffusion approximations in the device can be obtained by simply manouvering the injection level. Hence, the injection level dependence of the magnetic change in negative resistance and inductance has also been examined in this chapter.

The theoretical proposition about the magnetic change in negative resistance and inductance has been confirmed through our experimental results. It has been observed that aforesaid parameters change drastically in magnetic field, i. e. 100-200% at a field of about 1T. Other interesting features of our experimental results are that the magnetic changes in negative resistance and inductance increase with magnetic field (for a fixed injection level) and injection level (for a fixed magnetic field) which later on start decreasing after reaching an optimum value. These facts have been explained by considering the influence of transverse diffusion current and longitudinal minority carrier concentration gradient which appear to dominate at high magnetic field and current levels respectively. The orientational dependence of the magnetic change of these parameters have also been experimentally observed and are attributed to the asymmetric structure of the device. From these results it is concluded that the magnetic influence of life time is the primary reason underlying the magnetic changes in negative

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resistance and inductance. On the basis of this study, a magnetic field dependent unijunction transistor sine wave oscillator has been examined both theoretically and experimentally. The advantage of this study lies in the fact that the information regarding magnetic field is in a. c. form and therefore the magnetosensitivity can be easily enhanced by amplification.

One of the most enterprising property of unijunction transistor is its switching speed which is governed by at least two time constants. These time constants which determine the lower and upper limits of switching speed are the effective life time of minority carriers and their transit time in UJT bar. Both are obviously affected by the presence of magnetic field. Consequently, the effect of magnetic field on the switching speed of unijunction transistor needs a thorough examination. This aspect of the device has been covered in the IV Chapter of this dissertation through the study of the transient response of the device under magnetic field. For this purpose, the turn on time, turn off time, amplitude and half width of the current pulse have been studied when the device operates in relaxation mode with a capacitive load.

Initially the mathematical formulation for the problem has been attempted considering the discharge of a capacitor through the device negative resistance, inductance end externally connected resistance. In the present analysis, an average value of negative resistance and inductance were assumed for the simplicity of the problem. Later on, the expressions for the magnetic changes in the aforesaid parameters have been developed on the basis of the magnetic changes in negative resistance, inductance and static electrical parameters of unijunction transistor.

For the experimental verification of these results a unijunction transistor relaxation oscillator is assembled and the above mentioned parameters are measured on the voltage pulse waveform appearing at base one contact. The experimental results indicate the decrease of the amplitude of the current pulse and turn on time and an increase of turn off time significantly (nearly 100-200% for 1T magnetic field). The half width of the current pulse also shows a considerable increase in its magnitude. Orientational dependence of these parameters are also exhibited by the device. All these experimental results have been explained in terms of the magnetic changes in inductance, negative resistance and other parameters which all are mainly determined by effective life time of minority carriers.

The next chapter deals with the study of the application potentiality of unijunction transistor as a magnetic transducer, based on the

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results of Chapter II. It has been indicated in Chapter II that in a particular orientation of the device in magnetic field, the peak point voltage decreases and valley point voltage increases. Since the relaxation oscillator frequency of UJT is a function of both the parameters, it can be applied for realising greater frequency magnetosensitivity. To enunciate this feature, a theoretical and experimental study of unijunction transistor relaxation oscillator under the influence of magnetic field has been carried out in this chapter. Further, the effect of external circuit elements of relaxation oscillator on its magneto response have also been studied. All the magnetic changes have been interpreted in terms of the magnetic changes in static parameters of the device and have been verified experimentally.

The knowledge attained here has been further exploited in the design and construction of a low cost, reliable and sensitive semidigital magnetic fluxmeter. One of the desirable conditions of all electronic equipments is their functioning in a large range of ambient temperature. For this purpose, the magnetofrequency of relaxation oscillator has been examined as a function of ambient temperatures. On the basis of the so obtained experimental result, a sensistor in the base one arm of unijunction transistor has been suggested as suitable means of temperature compensation. Finally, a magnetic fluxmeter has been designed based on the comparator technique in which the magnetic field is related to frequency controlling variable resistance required for obtaining the balance condition. Magnetosensitivity of the fluxmeter developed in the laboratory has a value of about 10 K ohm T^{-1} in the linear range of the calibration curve.

Finally, Chapter VI outlines the major contribution of the present study and future prospects of the device. As the sensitivity towards magnetic field is a vital point for any magnetic transducer, various means of enhancing the magnetosensitivity of UJT have been mentioned. Some of them are the fabrication of the device on high resistivity silicon film grown on sapphire substrate and irradiation with high energy particles. In addition to this, mention has been made of the possible application of UJT in detecting small alternating magnetic fields ($\sim 10^{-10}$ T) which are encountered in human magnetism, fluctuations in terrestrial magnetism etc.

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CHARACTERIZATION AND GENERATION OF STATES AT THE SI-SIO_2 INTERFACE

Ram Janma Singh Sup. : *Dr. R. S. Srivastava*

The nature of real surfaces is of great practical imortance and has been the subject of serious investigations especially its electrical properties. Due to advent of planar technology, Si-SiO_2 interface has been perhaps the most thoroughly and extensively studied interface. For the successful realization of several electronic devices such as MOSFET, CCD, high frequency transistor etc. in the form of LSI on Si wafers, it is necessary that the density of surface states should be as small as possible. It may be pointed out that in late thirty's field effect device was conceived, however, due to large density of surface states at the surface, it was not realized then.

Generation and passivation of interface states due to different external agencies control the stability of planar devices especially, those which are used in space vehicles. The motive of the candidate was to study the distribution of interface states in the bandgap of Si and their generation by ionizing radiation and field stress.

The thesis consists of six chapters. Chapter I gives an introduction to the states at the Si-SiO_2 interface. Theoretical aspects of surface state capacitance and conductance are discussed in this chapter. Critical review on the most recently developed techniques for the determination of surface states, effects of radiation on these states and the role of interfacial layer in MIS solar cells are also given.

Chapters II-VI have been devoted to the studies carried out by the candidate. In Chapter II, various experimental techniques used for the fabrication of MOS devices are described. A brief description of the various annealing processes used is also given.

In Chapter III, experimental results on the investigation of surface state density at Si-SiO_2 interface using capacitance-voltage (C-V) and conductance-voltage (C-V) methods have been presented. The results have been divided into three different sections. In secton-A, distribution of surface state in the bandgap of Si from the study of C-V and C-V characteristics is presented. Admittance measurements on n-type MOS capacitor indicate a large density of surface states near the conduction band edge and a small hillock of surface state density near the midgap of Si. The conductance peak related to the surface states near midgap was found to be sensitive to temperature. These states have been associated to the dangling bonds of Si at the interface.

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The time constant and the capture cross-section of these states were found to be different than those lying near the Si conduction band edge side. In section-B, the response of the surface states at Si-SiO_2 interface has been studied. The results presented show that the effective density of surface states responding to the different a. c. signal frequencies is proportional to the log $\omega - \omega$ being the angular frequency of the probing signal. In section-C, the effect of temperature on surface states at Si-SiO_2 interface has been presented. The effective density of surface states obtained at any elevated temperature was found to be considerably larger than that obtained at low or room temperature.

Chapter IV deals with the comparison of the different techniques for the characterization of surface states at Si-SiO_2 interface. The study presented in this chapter has been divided into three different sections-A, B and C. In section-A, comparison of the result obtained by three different techniques viz., Hill-Coleman conductance technique. Nicollian-Goetzberger conductance technique and Castagne-Vapaille capacitance technique are presented. Various samples having surface state density of varying magnitudes were analysed. From the analysis, it has been concluded that Hill-Coleman technique is simple and gives results close to the one obtained from the most accurate method of Nicollian-Goetzberger. In Section-B, distribution of surface states based on Hill-Coleman conductance technique is presented. Capacitance and a. c. conductance versus gate bias curves were measured at different signal frequencies. Peaks obtained in the G-V curves for different singal frequencies were found to appear at different gate biases. This behaviour of the curves was utilized for the determination of surface state density at different surface potentials. Determination of surface state density for different surface potentials was also done by Nicollian-Goetzberger technique and the results compared. In section-C, experimental technique recently developed by Poon and Card was used for the determination of the energy distribution of interface states at the Si-SiO_2 interface using Al-SiO_2-nSi structure with thin oxide ($\sim$38 Å). This type of structure received attention in the past due to its potential application as solar cell and also as a tool for the investigation of the interface state parameters. In this method, quasi-Fermi level of the minority carriers at the surface is used to probe different energy positions in the bandgap. This level depends on the net external injection rates i. e. the rate of photogeneration of carriers and their tunnelling capability through the insulator. Since, the quasi-Fermi level of the minority carriers can be changed by varying the intensity of optical illumination, the entire bandgap of the semicon-

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ductor can be explored using such MOS structures on only one type of substrate. This is a definite advantage against the need for two MOS capacitors-one on n-type and the other on p-type silicon of exactly the same conductivity having identical nature of interface (a condition difficult to achieve) for obtaining these results by the conventional Nicollian and Goetzberger technique. The distribution of the surface state obtained in the lower half of the bandgap of silicon was distorted U-shaped The distortion in the lower half of the bandgap was more pronounced. Surface state density in the structure studied ranged from 6×10^{11} to 10^{12} $eV^{-1}cm^{-2}$.

The study presented in Chapter V has been divided into two sections, i. e. A and B. In section-A, experimental results obtained due to the X-ray and UV irradiation on MOS capacitors are presented. Although, the radiation dose was given to the structure without any externally applied electric field to the system yet, the results obtained are quite similar to those reported by the authors who irradiated the structure by UV and electron beam pulses under suitable external biases. Changes in the C-V and G-V characteristics due to different doses of X-ray were somewhat peculiar. It is almost certain that the surface states are generated in a systematic manner, i. e. higher doses of X-rays produce higher density of surface states Magnitude of the surface state density was calculated by Terman method. G-V curves were also measured simultaneously which also corroborated the results obtained by C-V curves. Chronological annealing of the newly generated surface states was also studied. The annealing of the surface states was found to be slow, however, annealing effect was found to speed up when the structure was irradiated with UV. In section-B, results on the generation of interface states when MOS structure was subjected to alternating electric fields of different amplitudes in rhe presence of intense visible radiation are presented. A correlation between the number of newly generated interface states and the amplitude of the cycling voltage has been found. Part of the surface states generated by relatively low a. c. cycling amplitude were relaxable with time. The cause of the generation of interface states at the $Si-SiO_2$ interface has heen associated to the hot electrons and holes injected into SiO_2 by the comparatively large amplitude of the alternating voltage.

In Chapter VI, results of experimental study on the photovoltaic properties of MOS structures are presented. This chapter is divided into two sections. In the study presented in section-A, emphasis has been laid on the mechanism responsible for the pho ovoltaic effect in

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devices having non-uniform oxide thickness. From dot to dot, the observed short-circuit current (I_{sc}) and open-circuit volage (V_{oc}) were found to vary by large amounts, while the dot area was almost the same. It may be mentioned that the author observed a peculiar rather suprising behaviour of the different MOS structures fabricated on the same wafer. Some dots showed positive V_{oc} and I_{sc} whereas most of the dots showed negative values of V_{oc} and I_{sc} as expected from the MIS structure in the inversion mode. The results obtained on two separate dots showing opposite polarities under optical illumination are presented. In section-B, experimental results on the degradation of p-MOS solar cell due to the application of alternating voltage stress of different amplitudes are presented. Both the short-circuit current and open-circuit voltage were found to decrease by 85% when the structure was stressed by and alternating voltage of 80 V amplitude for nearly 10^6 cycles. The degradation of solar cell has been attributed to the generation of surface state at the interface. It is discussed that in the case of MOS structures on p-type substrate acceptor type of states would help to separate the generated minority carriers toward favourable side. This would result in the improvement of the efficiency of the cell. In contrast to this, if the surface states present were of high density and of donor type i. e., they acquire positive charge, reverse effect would result. From the results presented in this study, one can presume that the surface states generated by the a. c. cycling voltage treatment were mostly of donor type. This inference finds support from the observed negative shift in the C-V curves with respect to unstressed one.

RADIATION BIOPHYSICAL STUDIES ON NUCLEIC ACIDS AND NUCLEOPROTEIN COMPLEXES

T. P. Ramachandran Sup : *Dr. S. Srinivasan*

The present studies were undertaken with a view to examine the alterations produced in salmon sperm DNA and salmon sperm nuclei as a consequence of irradiation of these molecules with cobalt-60 gamma radiations on the one hand and by UV radiations on the other. Structural changes, primarily the hydrogen-bonded base pairing and the vertical base stacking interactions were examined by taking recourse to physico-chemical aspects such as the dye induced fluorescence, spectral changes, hyperchromicity and circular dichroism. The melting tempera-

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ture and the energy status of the macromolecules in question were studied by the optical melting technique.

The number of EB binding "sites" was obtained by measuring the progressive increase in the fluorescence of the macromolecule-EB complex at 584 nm, with 520 nm as the excitation wavelength. A reduction was found in the number of binding sites from 19.5/100 nucleotides for the native DNA to a value of 10.6 for the nucleic acid irradiated to 600 krads with values falling in between for intermediate doses. A similar trend was seen in the case of sperm nuclei, for which however, the number of sites for native molecule was found to be 11.6. Values were obtained for the heat denatured and UV irradiated DNA and nuclei. These studies indicate a reduction in the hydrogen-bonded base pairs following irradiation.

Hyperchromicity studies led to the observation that following irradiation there is a decrease in the hyperchromicity value of 0.288 for native DNA to 0.089 for the nucleic acid irradiated with values falling in between for intermediate doses. Salmon sperm nuclei also followed the same trend, with however a lesser magnitude in the decrease in hyperchromicity. These studies in conjunction with the results from EB binding studies show that there is debase stacking in addition to debase pairing following irradiation of the macromolecules in question.

Circular dichroic measurements leading to the positive Cotton peak height, the first crossover wavelength confirm the findings from the other studies reported above. The mean residue molecular ellipticity [θ] from a value of 261.3 for the native DNA progressively decreased with increasing extents of irradiation, to 211.3 for DNA irradiated to 600 krads of gamma radiation. Likewise the first crossover wavelength of 254 nm for the native DNA shifted towards the longer wavelength to 256.5 nm for DNA irradiated to 600 krads. A progressive reduction in the area under the positive Cotton peak associated with increasing extents of irradiation was observed. A similar result was obtained for the rotational strength. Salmon sperm nuclei also exhibited the features described above, though somewhat to a lesser extent.

Optical melting studies followed by the analysis of the data therefrom showed that there was a decrease in the "melting" temperature of the nucleic acid from 68°C for the native DNA to 53°C for DNA irradiated to 600 krads with values falling in between for the intermediate doses. From "van't Hoff considerations", the energy status was seen to progressively decrease concomitant with irradiation pointing

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to structural destabilization as a consequence of irradiation of the macromolecules in question.

The results detailed above obtained from the methodologies cited in these studies are in consonance with each other. From these studies it is concluded that gamma irradiation of salmon sperm DNA and salmon sperm nuclei leads to debase pairing and debase stacking accompanied by a reduction in the energy status of the macromolecules in question.

EQUILIBRIUM THEORY OF SEMICLASSICAL FLUIDS

Yogesh Singh Sainger Sup. : *Dr. Y. Singh*

The problem of the statistical theory of fluids are of general type : characteristic of the so called N-body theory. Considerable progress has been made in solving these problems in last two decades. In particular, the computer experiments such as the *Monte Carlo* (MC) method which evaluates *ensemble average* in the sense of statistical mechanics, and the *molecular dynamics* (MD) method in which the dynamical equation of motion of the molecules are solved and *time averaging* is used have played a major part in this progress. Their importance, from the theoreticians point of view, rests largely on the fact that they provide essentially exact quasi experimental data on well defined potential models. As there is no certainty about the form of the interparticle potential, theoretical results can be tested unambiguously in a way which is not possible with data obtained in experiments on real fluids.

The theoretical methods developed in last two or more decades to explain and predict the equilibrium properties of classical fluids include *scaled particle method*, the *Percus-Yevick theory*, the *hypernetted chain* and various *perturbation schemes*. However, when dealing with fluids in which the deviation takes place at a microscopic level from the classical laws, our theoretical understanding is not so satisfactory. In the present thesis an attempt has been made to develop a theoretical method, employing the techniques already developed in the classical statistical mechanics, to deal with such fluids.

Apart from the typical quantum liquids ^4He and ^3He, which remain liquid down to zero temperature, there are some fluids, such as hydrogen and neon, for which quantum mechanical deviations from

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classical behaviour are observed at low temperatures. These deviations arise due to the diffraction effects, which are linked with the wave nature of the particles (Bose-Einstein or Fermi-Dirac) obeyed by the particles. The exchange effects are very small for all liquids except for liquid helium below 5° K. The diffraction effects, on the other hand, are appreciable at higher temperatures. In the present dissertation we are primarily concerned with the diffraction effect and confine our study to the temperature and density regions where quantum effects are small and can be treated as a correction to the classical system.

The subject material presented in the thesis has been divided into six chapters. In Chapter 1, the basic problems associated with the quantum fluid are discussed alongwith a review of the semiclassical theory of fluids. The first few sections of this chapter describe the two-and three-body modified Ursell functions for hard sphere potential model is also discussed. The last section is devoted to describe the cluster expansion method for the equilibrium properties of semiclassical fluids.

In Chapter II, using the grand canonical ensemble and functional differentiation technique, we derive the cluster expansion for the correlation functions. The resulting cluster series is summed using the Percus-Yevick approximation. We use this integral equation theory to devise perturbation method for the evaluation of the quantum corrections to the radial distribution function. These expressions of the quantum corrections to the radial distribution function have been used to obtain the expressions for the free energy and equation of state. The theory is applied to calculate the properties of the hard sphere fluid in the semiclassical limit.

In Chapter III, we use the hypernetted chain (HNC) approximation to sum the cluster series obtained in Chapter II. This used to devise perturbation method for calculating the quantum corrections to the radial distribution function. The explicit expressions for the free energy and equation of state are obtained under the HNC approximation. The theory is applied to calculate the properties of the semiclassical fluid of hard spheres. The results under different approximations have been compared and discussed.

Chapter IV describes the cluster expansion method for the equilibrium properties of the two-dimensional fluid. Explicit expressions for the RDF and free energy for the two dimensional fluid with non-analytic potential are reported. Results for the RDF, free energy and equation of state are evaluated for a two-dimensional hard disc fluid.

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The effect of the dimensionality on the quantum effects is also discussed.

In Chapter V, we consider the hard disc fluid and use the HNC integral equation perturbation theory to calculate the first order quantum correction to the RDF, and the first and second order quantum corrections to the free energy and equation of state. Comparison has been made with the results reported in Chapter IV.

The last Chapter is devoted to study the quantum effects on the distribution function and thermodynamic properties of a two-dimensional fluid whose molecules interact via a hard core plus an attractive tail potential. Explicit expressions for the RDF and free energy are given. We also derive the expressions for the density independent part of the RDF and first-order density correction to it and apply them to the squarewell potential. In the last part of this chapter, we calculate the second and third virial coefficients for a two-dimensional hard core fluid in the semiclassical limit. We discuss the second and third virial coefficients for some specific potential models.

OPTICAL AND PHOTOACOUSTIC STUDIES OF SOME ORGANIC MOLECULES (NAPTHALENES, PARABENZOQUINONE, PYRIDINES AND BENZALDEHYDES)

Vishwa Nath Pandey Sup. : *Dr. S. N, Thakur*

The spectroscopic technique is used mainly for two purposes : namely the detection of atoms and molecules responsible for the spectra and for the studies of structural and radiative characteristics of atoms and/or molecules. The aim of the present investigations is to study the electronic spectra of some polyatomic molecules with a view to understand their radiative and non-radiative characteristics.

The polyatomic molecules with which this thesis is concerned exhibit electronic transitions which correspond to one electron excitations of the type $\pi^* \leftarrow \pi$ and $\pi^* \leftarrow n$. Both types of excitations tend to change the electron densities in the molecule leading to a change in the force field and consequently the vibrational frequencies in going from the ground to the excited electronic state. Further, there may be a realignment of the electron spins in the process of excitation, so that an excited triplet state may result. Both singlet-singlet and singlet-triplet transitions will be considered in this thesis.

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Radiative transitions from states higher than the lowest excited state of a given multiplicity, with rare exceptions, have not been observed. This lack of emission from higher energy states has been interpreted as being due to the socalled "radiationless-transitions". Two types of radiationless transitions have been identified, one in which the multiplicity of the state is not changed—known as Internal Conversion (IC) and the second in which radiationless transition takes the molecule from a state of one multiplicity to that of different multiplicity known as Inter System Crossing (ISC). Both types of transitions are, however, of importance in understanding molecular properties and during recent years special efforts to study non-radiative transitions have been initiated. In the present work also we have endeavoured to study such processes in several polyatomic molecules which are rather well studied in conventional manner and for this purpose the recently developed technique of photoacoustic spectroscopy has been used.

In photoacoustic spectroscopy (PAS), the sample (which may be in solid, liquid or gaseous state) is illuminated periodically by chopped monochromatic light, and the heat resulting from the relaxation processes in the sample warms a gas in contact with it, causing periodic pressure variations in the latter. These pressure variations in the gas are then sensed microphonically. The apparatus is described more fully in Chapter II. Using a monochromator and phase-sensitive detection, the spectrum of the incident light can be scanned giving the relative amount of heat and a phase angle (related to the overall relaxation rate) at each wavelength. The amount of heat generated at each wavelength while depending on the incident spectral intensity, is the end results of a large number ro-vibronic relaxations and the details of this relaxation process are not apparent. We measure the relative amounts of heat released upon irradiation by different wavelengths in the spectrum, and the phase angle between the light pulses and the pressure pulses. This phase angle gives us information about the overall rate of radiationless relaxation.

The first Chapter of the thesis deals with the theoretical aspects of the problem which are pertinent to the analysis of the electronic absorption, emission and the photoacoustic spectra of molecules reported in the thesis.

The experimental arrangement for recording the vapour phase absorption and phosphorescence spectra are described in the Chapter II. In addition the photoacoustic spectrometer and the experimental techniques for recording the photoacoustic spectra of the powder and

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liquid samples are also presented in this chapter. The use of alumina powder to avoid saturation effects in the PAS spectra is suggested on the basis of our observations.

The electronic absorption and emission spectra have been recorded under high resolution in the vapour phase to minimise intermolecular interactions. The assignments of vibronic bands have been made on the basis of their rotational contours characteristics of free molecules. The work on the high resolution electronic absorption spectra of 1- and 2-Hydroxynaphthalenes are contained in Chapter III. Vibronic activity has been observed in both cases and excited state vibrational frequencies have been correlated with the corresponding ground state vibrations in the light of sequence intervals.

In Chapter IV, high resolution vapour phosphorescence spectra of p-benzoquinone-h_4 and -d_4 have been vibrationally analysed. The rotational contour of the 0_0^0 band of deuterated molecule shows some weak features not present in the spectrum of the undeuterated molecule. Evidence of Fermi-resonance in the spectrum of p-benzoquinone-h_4 has been found but no such perturbation occurs in the spectrum of p-benzoquinone-d_4. The photoacoustic spectrum of p-bezoquinone-h_4 in powder and solution forms have also been reported.

The results of photoacoustic measurements in the UV-visible region on monoderivatives of naphthalene (with OH, F, Cl and Br as the substituents) in powder and liquid samples are reported in Chapter V. The photoacoustic signals and intensities of absorption peaks in optical absorption spectra of these molecules have been correlated with the nature of substituents. The photoacoustic signals in the region of $S_1 \leftarrow S_0$ absorption are found to decrease as the substituent is changed from F to Cl to Br to OH.

The PAS spectra of three isomeric aminopyridines and the three isomeric hydroxypyridines are given in Chapter VI and the PAS spectra have been analysed with the help of low resolution optical absorption spectra. A comparative study of the non-radiative processes in these molecules shows that spin-orbit coupling between the S_1^1 ($n\pi^*$) and the T_1^5 ($\pi\pi^*$) states is maximum in 4-aminopyridine and minimum for 2-aminopyridine.

Chapter VII contains the results of the photoacoustic studies of the three isomeric nitrobenzaldehydes and of p-chloro and p-bromo-benzaldehydes. An attempt has been made to analyse the spectra in terms of the singlet-singlet and singlet-triplet absorption procsses as known from the optical spectroscopy.

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STATISTICS

SOME STUDIES IN NON-SAMPLING ERRORS

K. K. Singh *Sup. : Dr. B. N. Bhattacharya*

Interest in the population problems of developing countries, has led scientists to develop and construct mathematical models as an aid to understanding the dynamics of population change. Since, fertility has been principally responsible for the current rapid growth, several investigations concerned with the formulation of models for its study have been carried out in recent decades. The stochastic models provide an insight into the chance mechanism of the reproduction process and are helpful in the appraisal of observed data to estimate some of the biological determinants affecting fertility. This thesis embodies formulation of stochastic models for describing the data on number of births occurring to couples in a specified interval and data on birth intervals.

There are five chapters. Chapter I presents a brief review of the development of stochastic models for number of births and birth intervals alongwith the description of the the contents of the subsequent chapters.

Chapter II deals with derivation of models to describe the number of births to women during interval (O, T) of length T, when the start of the observation is marriage as well as when it is a distant point since marriage. These models which are extensions of the models of Singh, Bhattacharya and Joshi (1973) (on a hypothetical model for number of births and its application, Journal of the Indian Society of Agricultural Statistics, New Delhi, 25, p. 91), Sheps and Menken (1973) (mathematical models of conception and birth, University of Chicago Press, Chicago), can suitably be applied to data for small periods of observation because the parameters are assumed to be homogeneous in time. The methods to obtain maximum likelihood estimates of the parameters are outlined. These models are applied to data of "Rural Development and Population Growth—A Sample Survey 1978" conducted by the Demographic Research Centre to study the trends in fecundability and sterility according to age of the female.

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In Chapter III, a probability model is proposed to describe the distribution of births to couples in first T years of marriage, when T is large and/or when couples use various methods of family planning. This model is derived on the assumption that conditional instantaneous risk of a conception, the incidence of foetal loss and the chance of attaining sterility following a child birth are functions of parity. The model is an extension of that given in Singh, Bhattacharya and Yadava (1974) (a parity dependent model for number of births and its application, Sankhyā). The application of the model in evaluation of family planning programme in terms of changes in the child bearing pattern is illustrated.

Chapter IV presents some modifications in the usual life table technique to analyse the data on the time of first birth and interlive birth intervals which are compiled from the birth histories of females, of varying marital durations, enumerated in a retrospective survey. The fact that females may not be exposed to the risk of conception immediately after child birth (or marriage in case of first birth interval) due to her stay in post-partum amenorrhoea period (or visits to parents immediately after marriage, a social custom which is observed in some rural parts of India) is taken into account. A method to obtain maxium likelihood estimates of the conditional risk of conception is given. An analysis of birth intervals using the above technique is carried out from data collected in the survey entitled "Rural Development and Population Growth–A Sample Survey 1978".

Under simplified assumptions a model is derived for an interior birth interval–a closed birth interval lying entirely within a given segment of marriage duration in Chapter V. It may also be used to describe closed birth intervals lying between two survey dates. Method to find out maximum likelihood estimates of the parameters are outlined. The application of the model is illustrated through three observed sets of data taken from a survey entitled "Rural Development and Population Growth—A Sample Survey 1978".

SOME ANALYTICAL MODELS FOR COUPLE FERTILITY AND THEIR APPLICATIONS

Keshari Kumar Singh — Sup. ; *Dr. A. K. Srivastava (External)*

The present thesis deals with some aspects of non-sampling errors. Studies regarding non-sampling errors play important role in

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any investigation. In the available literature, considerable attention has been paid towards the study and control of such errors. Among various aspects of non-sampling errors, response and non-response are most important. Obviously, they have received maximum attention.

In the early development, response and non-response errors have been dealt with separately. Recently in a series of papers Platek, Singh and Trembley (1977) (Adjustments for non-response in surveys), Platek and Gray (1979) (Methodology and application of adjustments for non-response) etc. have tried to study the problem of response and non-response simultaneously through a response-nonresponse error model. To deal with the problem of non-response, imputation appears to be an effective tool. One of the main purposes of imputation has been to make the data set complete. In fact, if the imputations are based on study character values obtained from respondents only then completion of data set appears to be the only objective of imputation. The use of auxiliary information in sampling from finite population, for improving the efficiency of estimators is well recognised. Its application for imputation purpose is expected to improve the performance of imputation. In the present thesis, some aspects of response and non-response errors have been investigated for imputation based on auxiliary characters.

The thesis consists of five chapters. In the first chapter an introductory background of non-sampling errors is given along with the review of related literature.

The response-nonresponse error model mentioned above is an ingenious technique to deal with the problem of response and non-response simultaneously. An essential feature of this model is the utilization of the concept of response probabilities. In Chapter II, an imputation procedure based on auxiliary information has been discussed with the help of response-nonresponse error model for non-response arising from complete enumerations. It is seen that the use of auxiliary information brings substantial improvement.

Chapter III, deals with the problem of imputation based on auxiliary information for a sample selected by simple random sampling without replacement. Two estimators have been proposed and their efficiencies compared.

In Chapter IV, we consider the problem of imputation based on auxiliary characters through predictive approach. This is a model based approach and has been considered by Royall in a series of papers as an alternative to the classical approach of estimation.

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Chapter V, deals with interpenetrating subsampling with the help of response-nonsponse error model. Interpenetrating subsampling due to Mahalanobis is a well known technique for estimating the enumerators contribution towards the varience of the estimate. A basic requirement of this approach is the equality of sample sizes for the subsamples. In the presence of non-response the subsamples are of unequal sizes. This problem has been considered here with the help of response-nonresponse error model.

The author believes that the results contained in the thesis may be of great help to other researchers engaged in the study of non-sampling errors.

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ZOOLOGY

BLOOD-BRAIN BARRIER (BBB) IN STRESS

Hari Shanker Sharma Sup. : *Dr. P. K. Dey*

Blood-brain barrier (BBB) maintains a suitable fluid environment for brain which is very much essential for the normal functioning of neurones. Even a slight change in the composition of the extracellular fluid (ECF) in which neurones bath, may lead to the impairment of neuronal functions. The presence of tight junctions between cerebral endothelial cells and absence of vesicular transport in cerebral capillaries mainly constitute the BBB whose permeability properties are very similar to that of an extended plasma membrane. Thus, various lipid soluble substances can easily traverse the barrier while, other substances which are essential for brain metabolism such as glucose and certain amino acids are transported across the barrier through facilitated carrier mechanisms.

However, under various neurological diseases, and in certain pathological or experimental conditions, the permeability of BBB is increased mainly due to increase in vesicular transport and/or occaonally by widening of tight junctions.

Recently, certain stressful conditions such as training in water maze, starvation, bilateral adrenalectomy and foot-electroshock have been reported to increase the permeability of BBB to various protein tracers, but the possible mechanism(s) are not yet clear.

It is well known that prolonged stress can lead to the development of various neurological disorders which are often associated with increased BBB permeability. When these observations are considered together it is likely that prolonged stress may produce neurological ailments through breakdown of normal BBB permeability.

Various vasoactive substances are released in circulation during conditions of stress among which prostagladins, noradrenaline, adrenalins and serotonin are considered to be of paramount importance in the involvement of stress reactions. The active involvement of serotonin in various neurological diseases (associated with increased BBB permeability) has been recently suggested. Serotoni *per se* can in-

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crease the BBB permeability following its administralion either into the systemic circulation or through intracerebroventricular route.

Therefore, in the present study, the influence of stress conditions (immobilization and heat exposure) was examined on the state of permeability using Evane blue and HRP as barrier tracer substances. Further the role of serotonin was assessed in relation to the increased BBB permeability in the above stress conditions as well as in the model experiments.

The results showed a close parallelism between increased BBB permeability and increased 5-HT level in plasma and brain. Thus the profound increase of both the permeability of BBB and 5-HT level occurred at the end of 8 hr period immobilization and that of 4 hr period of heat exposure. These effects were mainly evident in younger rats (60-80 g).

Further, it was observed that p-CPA, indomethacin, and diazepam pre-treatment prevented both the increase in BBB permeability and 5-HT level, whereas, cyproheptadine, phenoxybenzamine and propranolol prevented the increase in BBB permeability without preventing the increased 5-HT level. However, other drugs like dexamethasone, mepyramine and cimetidine were found ineffective in preventing either the increased BBB permeability or 5-HT level following stress. Moreover, the degeneration of central catecholaminergic or serotoninergic neuronal pathways with 6-OHDA or 5, 6-DHT, prior to stress, also not prevent the increased permeability of BBB in stress indicating that central catecholamine or 5-HT mechanisms are not involved.

The results with drug treatments suggest that increased 5-HT level in stress is mainly responsible for the increased BBB permeability which was subsequently confirmed in model experiments.

Thus, infusion of 5-HT (10 ug/kg/min for 8 min) into systemic circulation of anaesthetized rats had also increased the permeability of BBB to Evans blue and HRP in younger rats. This dose of 5-HT was calculated on the basis of level of 5-HT observed at the end of 8 hr following immobilization. In order to further study the role of 5-HT regarding its influence on BBB permeability, 5-HTP (a precursor of 5-HT) was administered in another group of rats. Increased permeability of BBB occurred 4 hr after injection of 5-HTP (150 mg/kg, i. p.) in conscious younger rats. This dose of 5-HTP was known to increase 5-HT 4-6 fold in whole body including brain.

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The increased permeability of BBB following 5-HT infusion (in model experiments), was also blocked following pretreatment with p-CPA, cyproheptadine, diazepam, phenoxybenzamine and propranolol. Blockade of extravasation of dye with vinblastine (an inhibitor of microtuble polymerase) pretreatment in stress as well as in model experiments suggests that 5-HT increases the BBB permeability by increasing the vesicular transport across cerebral vessels. 5-HT is known to increase the vesicular transport through c-AMP and infusion of cAMP has been reported to increase the vesicular transport in cerebral vessels. The results with aminophylline (a phosphodiesterase enzyme inhibitor) which caused an early extravasation of Evans blue dye in brain following stress, suggest a possible role of cAMP in increasing the vesicular transport.

Since, increased permeability of BBB following stress was observed only ofter 8 hr immobilization as well as after 4 hr heat exposure and profound release of prolactin has been reported in these conditions (which persists for several hours) therefore, in another series of experiments, the action of prolactin on increased BBB permeability following infusion of 5-HT, noradrenaline or adrenaline was examined by prior intravenous infusion of exogenous prolactin in anaesthetized rats. The dose of prolactin was calculated from the level of prolactin observed in plasma at the end of 30 min following immobilization.

The results showed that prolactin *per se* did not modify the BBB permeability but It had prevented the extravasation of tracers across cerebral vessels caused by these biogenic amines. This protective effect of prolactin remained for atleast 1 hr but almost disappeared at the end of 3 hr following its prior infusion. These observations indicate a protective role of prolactin on cerebral vessels against the influence of these biogenic amines under stressful conditions.

Summarily, it appears from the present study that increased permeability of BBB following immobilization and heat stress is closely related with the increased level of 5-HT (in plasma and brain) which inturn increases the BBB permeability following stimulation of vesicular transport across cerebral vessels and release of prolactin in these stressful conditions renders some protection against the influence of 5-HT and other neurohumoral agents (released in circulation) during these stress conditions.

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EFFECT OF HOMOEOPATHIC DRUG PULSATILLA ON REPRODUCTION OF RATS AND CONSEQUENTIAL CHANGES EXHIBITED BY NEURONS OF ARCUATE NUCLEUS

Saraswati H. Velicheti Sup : *Dr. (Mrs) K. Chandrasekhar*

Current interest centres around the exploration of a cheap and psychologically acceptable contraceptive. Voluminous data exists, still Briggs and Briggs (1976) say, "existing contraceptive methods have had so small an impact on world population explosion that few people can doubt the need for developing new methods. Only when a wider reange of products is available, to suit more groups of people, will there be a lessening of the rate of population increase" and "inspite of two decades or more researches there is a great demand for reapily acceptable and safe oral contraception" and other sterilization methods which could be at the disposal of the family planning units. The position has not changed much and the statement holds good even today.

Earlier data (Chandrasekhar and Prasad, 1976; Prasad and Chandrasekhar, 1978a, b) found 30 and 200 potencies* of *Pulsatilla nigricans*** possessing progesterogenic properties. Therefore, it was felt that an indepth study using the higher potencies of *Pulsatilla nigricans* may yield better and useful results. This investigation was taken up with the idea of finding its antifertility effects and its effects on the arcuate neurons which is the seat of LH-RH secretions.

100±10 gms of regularly cycling albino rats of HM strain were collected. All set norms of experimental procedures were strictly adhered.

The findings in the first experiment are : 1,000 potency of *Pulsatilla nigricans* reduced ovarian and uterine weights, decreased the number and diameter of corpora lutea, luminal epithelial cell height and endometrium. The arcuate neurons did not exhibit any particular deviation from the normal cyclic changes, as a result of drug administration.

1,000 potency of *Pulsatilla nigricans* reduced the duration of estrous cycles from 5 to 3 days. The movements of the normal and experimental groups tallied, while the alcohol fed controls exhibited faster movements (excited).

* Potency : Various potencies are prepared from the mother tincture–the alcoholic plant extract.

** *Pulsatilla nigricans* is a plant belonging to the family Ranunculaceae.

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In second experiment, where quantitive alterations in lipid contents, succinic dehydrogenase (SDH) and alkaline phosphatase activities were conducted, confirmed the histological assessments in Chapter I.

A third test the drug's effect on implantation of blastocysts showed that it interrupts implantation by causing auto-immuno reaction and the consequent resorptions of the blastocysts.

Earlier work (Prasad and Chandrasekhar, 1978) revealed *Pulsatilla nigricans* to effect partial thyroid disfunction and impairement in reproduction. Therefore, tests were conducted to study the effect of the drug on hypothyroid mothers. In the absence of thyroid hormone the drug brought about total resorption of the foetuses even in the advanced stages of pregnancy. Prevention of defective births in hypothyroid mothers seems to be the etiological significance.

ROLE OF PROSTAGLANDINS IN RENAL FAILURE

Gulab Chand Sup. : *Dr. P. K. Srivastava*

The composition of the internal environment i. e. body fluids, in which cells and tissues of an organism are continuously bathed and perform their various activities, is maintained in optimal range by so called KIDNEY. It is obvious that an impairment in renal function will lead to changes in fluid within the cells and, in turn, also in cell function. This improper functioning of kidney is known as RENAL INSUFFICIENCY which can manifest in forms of the following two pathological conditions—

(1) Acute Renal Failure

(2) Chronic Renal Failure

The role of prostaglandins, a lipoid hormone, in the control of renal physiological processes is an important and fruitful area for continued investigation. In our country, studies are very meagre. No attempt has been made previously to understand the role of circulatory PG level in relation to either normal renal function or pathological states of kindey. Taking all the considerations into account, the present project is a small effort to fill up the lacuna by studying the role of prostaglandin in ARF, CRF and electrolyte homeostasis. The

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present study has revealed the effect of prostaglandin like activity in relation to—

(1) Age and sex variation

(2) Type of renal failure

(3) Severity of renal insufficiency

(4) Serum electrolyte profiles (sodium and patassium)

(5) Duration of onset of deteriorating uraemic symptoms

(6) Blood pressure changes (Hypertension)

The following points are important in summarising the present study—

(1) The present study aims at working out the role of prostaglandins in acute renal failure (ARF) and chronic renal failure (CRF) in relation to their various clinical parameters.

(2) This study consisted of the assessment of renal function and the total plasma prostaglandin like activity in series of 218 subjects including 50 normal volunteers, 134 cases of chronic renal failure and 34 cases of acute renal failure.

(3) The assessment of renal function in the present study consisted of the determination of blood urea nitrogen (BUN) level, serum creatinine level and serum electrolyte (Sodium and Potassium) profiles besides the clinical assessment including Blood Pressure changes and duration of onset of deteriorating uraemic symptoms.

(4) The plasma prostaglandin like activity was determined in terms of PGE_1 by bioassay on guinea pig ileum. The extraction of prostaglandin was done by the method described by Unger *et al* from human blood.

(5) The data emerging out of the present investigation did not show any significant difference in plasma prostaglandin like activity in normal subjects in relation to age and sex.

(6) The PG-like activity was found to be significantly lower in patients of renal failure than the normal subjects. Ths rate of decrease in the activity of prostaglandins was more pronounced in cases of ARF as compared to the cases of CRF. This decrease in PG-like activity, may be due to—

(i) decreased synthesis

(ii) increased degradation and/or

(iii) increased urinary excretion.

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In the present series we have studied only PG values, so we can not be too sure for the rest of the two factors because uraemia being a metabolic disorder, affects the various homeostatic mechanisms.

(7) A comparative study between the status of renal functions and the level of plasma prostaglandin like activity indicates a positive correlation between the rate of lowering of plasma prostaglandin like activity and the rate of deterioration of renal function as is obvious from the following observations—

(a) The plasma prostaglandin like activity was found decreasing in relation to the rising level of serum creatinine significantly.

(b) Similarly the plasma PG-like activity was found decreasing with the increasing blood urea nitrogen level.

(c) There was an evidence of negative correlation between plasma PG-like activity and serum sodium profiles in APF and CRF.

(d) A similar negative correlation was observed between the levels of serum potassium level and plasma prostaglandin like activity in patients of renal insufficiency (ARF & CRF).

(8) An overall assessment revealed no significant relationship between the plasma PG-like activity and the duration of onset of deteriorating uraemic symptoms.

(9) The rate of decrease in plasma PG-like activity was found more pronounced in hypertensive patients of renal failure as compared to those who were normotensive in the same series.

(10) The lower PG-like activity, if present due to some extra renal factor, is likely to be injurious to the kidneys because prostaglandins have a notable vasodilation and defficiency of these chemical substances may permit to increasing vasotomia with rising blood pressure and ischaemic changes in vital organs including the kidney.

(11) Thus the decrease in plasma prostaglandin-like activtty, as seen in the present series may be the causal factor as well as the effect of renal failure.

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EFFECT OF VARIOUS ENVIRONMENTAL FACTORS ON NERVOUS SYSTEM IN TISSUE CULTURE WITH SPECIAL REFERENCE TO HYPOTHALAMUS

Mridul Srivastava Sup. : *Dr. G. C. Prasad*

(1) Various environmental factors are known to effecf the function of central nervous system. This study was undertaken to observe the effect of stress i. e., chemical and electrical stimuli on the hypothalamus *in vivo* as well as *in vitro* by organotype culture.

(2) To standardise the culture technique, hypothalamus was cultivated in different nutrient media i. e., B. G. J. and Dulbacco's Modified Eagle's Media. Explants were grown for different durations i. e., from 2 hours to 6 days. It was found histologically that the hypothalamic tissue survived for a longer duration in Eagle's medium and neurosecretory cells were found to be visible for 2 hours only in both the media.

(3) Our experimental design included the exogenous administration of certain neurohumors i. e., acetylcholine, noradrenaline and 5-HT in effective doses and physical stress viz., electric shock. The hypothalami were subjected to the histological, histofluorescence, biochemical and isotopic studies.

(4) Biochemical and isotopic study of used culture media were also done.

(5) In *in vivo* study, different neurohumors were injected intraperitonially in the following doses i. e., acetylcholine 10/ug/25 g body weight, NA 2.5/ug/25 g body weight and 5-HT 10/ug/25 g body weight separately for 7 days. In *in vitro* study, the hypothalami were cultured for 2 hours in media containing different neurohumors in effective doses i. e., acetylcholine 1/ug/ml, noradrenaline 0.25/ug/ml and 5-HT 1/ug/ml respectively.

(6) Physical stress was induced in mice by passing 30 volts intermittant current daily for 7 days *in vivo* and 1.5 volt for 1 hour *in vitro* in a special model devised.

(7) The effect of antistress agent i. e., diazepam on neurohumoral content of hypothalamus was studied alone and with electric shock, both *in vitro* and *in vivo* conditions.

(8) After 7 days of neurohumoral, diazepam and electric shock treatment in the *in vivo* experiment and after 2 hours in the *in vitro* experiment, the hypothalami wero subjected to biochemi-

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cal, histological and histofluorescence studies. The used culture media were also subjected to biochemical analyses.

(9) The biochemical estimations done were, acetylcholine, catecholamine, MAO, GABA, glutamate and aspartate. The histological study of neurosecretory cells using aldehyde fuchsin stain was also done. The histofluorescence study for localization of catecholamine was also performed.

(10) Apart from these studies, isotopic study was carried out where ^{3}H-Ltryptophan was injected intraperitonially, half an hour before sacrificing the animal. The percentage of ^{3}H-Ltryptophan uptake by the hypothalamus *in vivo* and *in vitro* and release into the culture media was estimated after neurohumoral, diazepam and electric shock treatments.

(11) The result of the present study on acetylcholine estimation in hypothalamus after treatment with neurohumors *in vitro* revealed an increase in acetylcholine content after acetylcholine treatment and decreased after noradrenaline treatment. No significant change was observed after 5-HT treatment. Similarly, acetylcholine level was higher in acetylcholine treated used culture medium and lower in noradrenaline treated and absent in 5-HT treated used culture medium. The *in vivo* finding were corroborated by the *in vitro* findings, where similar results were observed after acetylcholine and noradrenaline treatment, whereas the acetylcholine level was found to be decreased significantly in hypothalamus after 5-HT treatment.

(12) Regarding the catecholamine, it was found that the hypothalamic catecholamine content decreased after acetylcholine and 5-HT treatment and increased after noradrenaline treatment *in vitro*. On the contrary, the catecholamine content of hypothalamus increased significantly after 5HT treatment *in vitro*. Acetylcholine and noradrenaline showed similar results as observed *in vitro*. Catecholamine was absent in control, 5-HT and acetylcholine treated used culture media, only little amount was present in noradrenaline treated used culture medium.

(13) Further GABA and glutamate estimation of the hypothalamus after neurohumoral treatment revealed increased level of hypothalamic GABA after acetylcholine treatment and decreased level after noradrenaline and 5-HT treatment both *in vitro* and *in vivo*. On the other hand, GABA was absent in the acetylcholine treated used culture medium and increased in noradrenaline and 5-HT treated

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used media. On the contrary, the glutamate content of hypothalamus decreased after acetylcholine treatment and increased after noradrenaline and 5-HT treatment both *in vitro* and *in vivo*. At the same time it was absent in acetylcholine treated used culture medium and decreased in noradrenaline and 5-HT treated used media. This indicates the conversion of glutamate into GABA after acetylcholine treatment. Noradrenaline and 5-HT inhibits the synthesis of GABA from glutamate.

(14) Isotopic study revealed decrease in percentage uptake of ^{3}H-Ltryptophan after all three neurohumoral treatment i. e., acetylcholine, noradrenaline and 5-HT both *in vitro* and *in vivo*. The decrease was maximum after acetylcholine treatment. At the same time the level increased in the used culture medium. This denotes decreased synthesis of 5-HT and decreased utiization of its precursor amino acid.

(15) In the electrical stress study *in vitro*, there occurred a marked fall of acetylcholine level in hypothalamus and increased level in used culture medium. The *in vivo* study further corroborated with *in vitro* study, where similar results were observed. This indicates that electric shock produces excessive release of adetylcholine from the hypothalamus into the medium and presumably into the blood.

(16) Similar to acetylcholine, the catecholamine level also decreased in hypothalamus after electric shock treatment both *in vitro* and *in vivo*. At the same time it was absent in used culture medium. It indicates increased turnover and utilization of catecholamine after electrical stress. This study was further strengthened by the histofluorescence study, where decreased catecholamine fluorescence was observed.

(17) On the contrary to the catecholamine and acetylcholine, the GABA and glutamate level was increased in hypothalamus after electric shock stress both *in vitro* as well as *in vivo*. At the same time, GABA was absent in used culture medium and glutamate level was decreased.

(18) Similar to GABA and glutamate, the ^{3}H-Ltryptophan level was increased in hypothalamus after electrical stress both *in vitro* and *in vivo* and decreased in used culture medium. This indicates the increased synthesis of 5-HT in hypothalamus after electrical stress.

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(19) Diazepam, a known antianxiety, antitension and antistress agent, when administered exogenously revealed an increased level of acetylcholine in hypothalamus *in vitro* as well as *in vivo*. The increase was highly significant *in vivo* condition. At the same time acetylcholine was absent in the used culture medium. It indicates that diazepam increases the synthesis of acetylcholine and simultaneously it inhibits the release into the culture medium. When diazepam was adminstered with electric shock treatment, it nearly normalizes the acetylcholine level which had decreased by electric shock alone both *in vitro* as well as *in vivo*.

(20) Similar to acetylcholine, the catecholamine level was also found to be increased after diazepam treatment *in vitro* and *in vivo*. Simultaneous administration of diazepam with electric shock treatment revealed an increase in catecholamine level to near about the normal level, which had decreased significantly after electrical stress alone. This indicates that diazepam inhibits the stress-induced increased turnover of catecholamine. This study was further confirmed by the histofluorescence study.

(21) On the contrary the GABA and glutamate level decreased in hypothalmus *in vitro* and *in vivo* and increased in the used culture medium after diazepam treatment. When diazepam was introduced with the electric shock treated group, it decreased the previously increased level to near about normal level.

(22) The result of the percentage of ^{3}H-Ltryptophan uptake by the hypothalamus and release into the culture medium after diazepam treatment revealed decreased ^{3}H-Ltryptophan content in the hypothalamic tissue and an increase in the culture medium *in vitro*. The *in vivo* findings was also similar. When diazepam was administered with electric shok it normalizes the increased level of ^{3}H-Ltryptophan which was increased previously by electric shock. This may be due to the fact that diazepam inhibits the 5-HT synthesis.

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CLINICAL AND EXPERIMENTAL EVALUATION OF STRESS RESPONSE ON URINARY BLADDER DISTENSION IN NORMAL SUBJECTS AND PATIENTS OF STRESS DISORDER

Madhu Shukla Sup. : *Dr. S, N. Tripathi*

The term 'stress' has a very wide meaning and it is very difficult to define it precisely. According to Selye (1956), stress is a non-specific response of body to any demand made upon it, which may ba physiological, psychological or physical. Series of the changes taking place in response of stimulus or stressor are known as the stress response and include physiological, biochemical and behavioural changes. Response is initiated at the neurohumoral level which is followed by the other changes in order to cope with the stressful situation.

Since quite early, it has been demonstrated that distension of hollow viscera, like gall bladder, bile duct, urinary bladder and rectum etc., is capable to evoke cardiovascular responses and induce the release of hormones and physiologically active substances such as adrenaline, prostaglandins and vassopressin etc. in circulation. Recently it has been reported that increase in the sympathetic activity is due to bladder distension. All these responses are characteristic of stress and alteration in sympathetic activity in response to stressors is also an established finding. Hence in the present study levels of neurotransmitters in blood, urine and tissues has been investigated alongwith the phsysiological changes after distension of urinary bladder in clinical as well as experimental models. The whole study is summarized as follows :

(1) The whole study has been conducted in two parts, one consisting of clinical cases and other of experimental animal.

In clinical study, distension of urinary bladder was produced by the voluntary retention of urine leading to the accumulation of urine in the bladder. The subjects were given 1.5 litres of water to drink in order to ensure good diuresis. Clinical study has been carried out in two series of subjects; one consisting of the healthy normal subjects and the other series consisting of the patients suffering from various stress disorders such as hypertension, peptic ulcer, cardiovascular disease, and bronchial asthma. To observe the effect of urinary bladder distension in these subjects, their blood and urine samples were collected prior to drinking water and after maximum holding of urine and subjected for the biochemical estimations.

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(2) Biochemical estimations carried out in these experiments included estimation of acetylcholine (Ach) in RBC; catecholamine, serotonin (5-HT) and cortisol in plasma and histamine in whole blood. Cortisol and histamine has been estimated only in the patients of bronchial asthma. At the same time urinary levels of adrenaline, noradrenaline and 5-hydroxyinoleacetic acid (5-HIAA, metabolite of 5-HT) were estimated and expressed in terms of creatinine. Apart from these biochemical studies, some physiological variables such as blood pressure, pulse rate and respiration rate were also recorded before drinking water and after maximum retention of urine.

(3) In experimental study, the effect of urinary bladder distension has been observed in two respects. In one experiment the effect of urinary bladder distension has been observed at hourly intervals upto 5 hours in rabbits. Here, bladder distension was produced naturally by oral administration of water to ensure good diuresis. In the next experiment, the effect of graded distension of urinary bladder has been observed by distending the urinary bladder with 20 ml, 40 ml and 60 ml of distilled water pushed through urethral catheter directly into the bladder with a specific speed. Blood aneurine samples were collected from the animals of both the experiment, before as well as after bladder distension. Then, the animals were sacrificed for the collection of brain and adrenal tissue samples.

(4) Circulating Ach, catecholamine, serotonin, cortisol and urinary adrenaline, noradrenaline and 5-HIAA were estimated. Apart from these Ach, catecholamine and 5-HT were estimated in different regions of brain i. e. hypothalamus, thalamus, cortex and in adrenal glands. Adrenal gland weight was also observed. Arterial blood pressure change was observed with the help of mercury manometer by cannulating the femoral artery.

(5) Results of the clinical stduy of catecholamine estimations in blood as well as in urine revealed an increase in its level in the patients of stress disorders in comparison so the levels in normal healthy subjects. After retention of urine, there was an increase in the adrenaline as well as nonadrenaline levels of plasma and urine in normal healthy subjects and also in patients of hypertension, bronchial asthma and peptic ulcer. Although all the patients exhibited a greater magnitude of response in comparison to normals, maximum response was found in circulating catechola-

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mine of hypertensive patients. In the urinary catecholamine also, maximum response was observed in the patients of hypertensions while bronochial asthma and peptic ulcer cases exhibited more or less same degree of response at the normal healthy subjects.

(6) Observations regarding 5-HT, revealed an increased circulating level of this amine in the patients of hypertension, bronchial asthma and peptic ulcer as compared to the normal healthy subjects. Urinary 5-HIAA also exhibited an increased level in these patients which was significant only in the peptic ulcer subjects and insignificant in the patients of hypertension and bronchial asthma. After retention of urine, there was a significant increase in circulating 5-HIAA in normals as well as in patients of stress disorders.

(7) RBC Ach level was significantly increased in the patients of bronchial asthma and peptic ulcer in comparison to the normals. After retention of urine there was a slight decrease in Ach level of normals, hypertensives and peptic ulcer patients, while the bronchial asthma patients revealed a slight increase in Ach level. All these alterations were insignificant.

(8) Blood pressure was increased in the normal healthy volunteers significantly after urine retention but in the patients of stress disorders no significant change was observed, except in the patients of hypertension and cardiovascular disease. Pulse rate and respiration rate were significantly increased after retention of urine in normal healthy volunteers but in the patients of stress disorders these increase were not significant. This might be due to the small size of the series of hypertensives, bronchial asthmatics and peptic ulcer cases and high deviation in the variables. Urge sensitivity period of micturition i. e. time interval between drinking water and feeling of urge was maximum in the patients of bronchial asthma and minimum in the patients of hypertension.

(9) All these physiological changes after bladder distension alongwith the increased levels of catecholamins and 5-HT revealed that probably the increased neurohumors may be responsible for the changes in blood pressure, pulse rate and respiration rate. Available reports indicate the activation of the sympathetic nervous system during stressful situations to cope with the situation by supplying increased demands of energy and other factors.

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Similarly the increased 5-HT level probably helps an individual to suitably monitor various physiological functions of body and it is known to subserve the function of catecholamine in body by way of promoting blood circulation and allied effects.

(10) In experimental study regarding the effect of bladder distension at hourly intervals there was a significant increase in circulating noradrenaline (NA) at all the hours in comparison to the control or zero hour level. Increase was maximum after the 1st hour and then there was a decreasing trend in NA level, which was again increased after the 3rd hour of bladder distension. Similar trend of response was observed in the circulating adrenaline (A) but increase was not as significant as in noradrenaline. Urinary adrenaline and noradrenaline were increased significantly after bladder distension.

(11) Circulating 5-HT was also observed to increase after the distension of urinary bladder in comparison to control level. Increase was maximum after the lst hour distension. Urinary 5-HIAA also revealed a sigificant increase after bladder distension.

(12) RBC Ach was increased slightly after bladder distension in comparison to control but the change was insignificant.

(13) Observations regarding the effect of graded distension on blood pressure revealed an increase in the arterial blood pressure after distension of urinary bladder at all the volumes in comparison to the control level. The increase was maximum at the 40 ml distension. There was an increasing tendency in blood pressure upto 40 ml distension and then there was a decrease at 60 ml distension.

(14) Circulating adrenaline and noradrenaline, both exhibited an increase in their levels after bladder distension at all the volumes. Patterns of change revealed an increasing tendency upto 40 ml distension and then at 60 ml distension there was a drop in their levels. Apart from this, catecholamine level of brain also revealed a marked increase at all the distensions in comparison to control level especially in thalamus and cerebral cortex. The pattern of response in hypothalamus and thalamus were same while in the cerebral cortex there was a continuous increase in the catecholamine level with the increasing volume of distension.

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(15) Plasma serotonin level also revealed an increasing pattern after bladder distension at all the volumes in comparison to control. The pattern was similar to circulating catecholamine i. e. there was an increasing trend uplo 40 ml distension and then a drop in 5-HT level at 60 ml distension. Brain serotonin level was also observed to increase significantly after the bladder distension at all volumes, especially in cerebral cortex. In hypothalamus and cerebral cortex there was a high increase of 5-HT level at 20 ml and 60 ml distension which was slightly decreased at 40 ml distension. In thalamus there was an increasing tendency in 5-HT level with the increasing volume of distension.

(16) Circulating Ach was also increased after bladder distension at all the volumes in comparison to the control level. The increase was continuous upto 40 ml distension and at 60 ml distension there was a drop in Ach level. There was a decrease in Ach level of all parts of brain i. e. hypothalamus, thalamus and cerebral cortex. In thalamus and cerebral cortex the Ach level decreased continuously with the increasing volume of bladder distension, while in the hypothalamus the pattern of change was reverse i. e. at 20 ml distension decrease was maximum and minimum at 60 ml distension.

(17) Circulating cortisol increased after the bladder distension at all the volumes and the increase was continuous with the increasing volume of distension. Adrenal catecholamine level decreased continuously with the increasing volume of distension while adrenal 5-HT increased at all distensions. Weight of adrenal gland was reduced after the distension of urinary bladder which might be due to the discharge of excessive catecholamines in circulation.

(18) All these neurohumoral changes revealed that there was an alteration in the metabolism of these neurohumors and for better understanding and confirmation of the exact nature of these alterations, enzymatic study is further required. The changes revealed that there was activation of sympathoadrenal system which is one of the most important defense system of organism against any kind of stressor in order to cope with the situation. The increased level of 5-HT porbably helps an individual to monitor the physiological needs of an organism in stressful conditions. It assists in the functions of the catecholaminergic system. Besides this, 5-HT respons is known to operate through hypothalmo-pituitary axis and an activated hypothalmo-pitutary axis

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in stressful situation may be responsible for the production of 5-HT, which may in turn further accelerate the hypothalmo-pituitary axis. Insignificant change in circulating Ach and decreased brain Ach level indicate the suppressed activities of parasympathetic system which may be a specific response in order to maintain the bladder distension.

(19) On the basis of the whole study it was concluded that :—

(a) Voluntary retention of urine leading to urinary bladder distension is a potent stressor for human being because the physiological parameters of stress such as blood pressure, pulse rate, respiration rate, catecholamine and 5-HT levels were increased.

(b) Stress response induced by voluntry retention is capable of aggravating/precipitating stress disorders like hypertension, bronchial asthma and peptic ulcer in susceptible individuals.

(c) clinical and experimental both findings indicate that alterations in the neurohumoral levels might be the cause of physiological changes.

ENDOCRINOLOGY OF REPRODUCTION IN SOME IMPORTANT FOOD FISHES

Indra Jeet Singh Sup. : *Dr. T. P. Singh*

The present thesis consists of two sections. Section I deals with annual profiles of gonadotrophin in pituitary gland and blood serum, lipid and cholesterol in gonads, liver and serum of two most important food fishes of eastern Uttar Pradesh (India) viz., *Cirrhinus mrigala* and *Clarias batrachus*. Seasonal fluctuation in serum calcium, protein phosphorus and lipid phosphorus has also been studied in relation to annual reproductive cycle in above species. The second section embodies the effect of some non-steroidal ovulators (clomid, sexovid, PGE_1 and $PGF_{2\alpha}$) on gonadal and thyroidal functions along with gonadotrophic and thyrotrophic potencies and also on some biochemical changes related with reproduction. This experiment has been carried out with the freshwater catfish, *Heteropneustes fossilis*, which besides being economically important, is one of the most suitable experimental fishes of tropical India and various aspects of its reproductive endocrinology have been already explored to some extent.

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Section I

Studies on some endocrinological and biochemical changes related to gonadal development and reproduction in freshwater fishes viz., *C. mrigala* and *C. batrachus* have been reported in this section. Endocrinological study comprised of monthly estimations of pituitary and serum gonadotrophin levels for entire annual reproductive cycle which has been divided into following phases : resting phase (November-February), preparatory phase (March-April), prespawning phase (May-June), spawning phase (July-August) and regression or postspawning phase (September-October). Increase in gonadosomatic indices and pituitary gonadotrophin levels were simultaneous and became evident from March in both sexes of *C. mrigala* and *C. batrachus* but rise in serum gonadotrophin level was noticed one month later in April. Their peaks were observed in June-July. Serum gonadotrophin in either sex of both species and pituitary gonadotrophin in both sexes of *C. batrachus* and males of *C. mrigala* had started decreasing with the fall of GSI from September but high level of pituitary gonadotrophin in female *C. mrigala* continued till October. Variations in gonadal ^{32}P uptake were similar the changes in GSI values in either sex of *C. batrachus*. Results of ovarian ^{32}P uptake and induction of ovulation in hypophysectomized *H. fossilis* in response to pituitary extract revealed that pituitaries of female *C. mrigala* collected during breeding period were more potent than pituitaries from male. Pituitaries of both sexes of *C. mrigala* were more potent than bovine LH in inducing ovulation in hypophysectomized *H. fossilis*. Increase in gonadotrophic potency and GSI in *C. mrigala* and *C. batrachus* was associated with increasing photoperiod and temperature (from March) and continued increasing till June when photoperiod was longest and temperature was maximum. But peak level of pituitary and serum gonadotrophin was noticed in July coinciding with sudden drop in temperature due to heavy rainfall. Decrease in gonadotrophin level and GSI was simultaneous with decreasing trend of photophase and temperature (September onwards). Lowest level of gonadotrophin and GSI was recorded during December/January having shortest photoperiod and lowest temperature.

The biochemical study consisted of 1–annual profiles of lipid and cholesterol of gonads, liver and serum along with hepatosomatic indices in above species and 2–seasonal changes in serum calcium, protein phosphorus and lipid phosphorus levels for assessing vitellogenic activity in *C. mrigala* and *C. batrachus*. Hepatosomatic indices in *C. mrigala* and *C. batrachus* were minimum during April-

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August (breeding period-prespawning and spawning phases) and maximum during December-February (non-breeding period-resting phase). Annual changes in HSI and GSI showed inverse relationship. Liver lipid and cholesterol and serum cholesterol levels like HSI decreased during breeding and increased during non-breeding periods in either sex of *C. mrigala* and *C. batrachus.* Ovarian lipid and cholesterol contents (mg/ovary) as well as their concentrations (mg/g or 100 g of ovary) were high during breeding season in *C. mrigala* and *C. batrachus.* Testicular lipid and cholesterol demonstrated a different pattern of change. Lipid and cholesterol contents of testis were high during breeding season but their concentrations except cholesterol concentration in *C. mrigala* decreased during this period. Testicular cholesterol concentration in *C. mrigala* like its content was high during the above period (May-July). An inverse trend was observed between ovarian and testicular lipid and cholesterol levels during non-breeding season. During non-breeding season when GSI values were low, ovarian lipid and cholesterol levels were also low. Though testicular lipid and cholesterol contents were low during non-breeding period but their concentrations were high.

Levels of serum calcium, protein phosphorus and lipid phosphorus were high in females of *C. mrigala* and *C. batrachus* during prespawning and spawning periods and low during remaining periods. No such seasonal change was noticed in males.

Gonadal growth, maturation and spawning in *C. mrigala* and *C. batrachus* seems to be dependent on gonadotrophin secretion and entire process might be regulated by external environmental factors amongst which photoperiod, temperature and rainfall appear to be most important. Changes in lipid and cholesterol levels of gonads, liver and serum are related with the changes in reproductive cycle. Increased level of vitellogenin as reflected by rise in the levels of serum calcium, protein phosphorus and lipid phosphorus coincided with ovarian growth and maturation and increased gonadotrophin secretion.

Section II

This section deals with the effect of clomid, sexovid and prostaglandins (PGE_1 and $PGF_{2\alpha}$) on gonadal and thyroidal activities, gonadotrophic and thyrotrophic potencies and on some biochemical changes in ovary, liver and serum of *H. fossilis* during preparatory and postspawning phases of annual reproductive cycle. These drugs were ineffective in stimulating ovarian ^{32}P uptake during post-spawning period but except $PGF_{2\alpha}$, they induced ovarian ^{32}P uptake during

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preparatory phase. Overian ^{32}P uptake in hypophysectomized specimens of *H. fossilis* were affected neither in preparatory nor in postspawning phase. Clomid, sexovid, PGE_1 and $PGF_{2\alpha}$ were affective in increasing GSI values during preparatory phase but not during postspawning phase. These drugs increased pituitary gonadotrophin was observed only in response to clomid treatment during preparatory phase. But pituitary and serum gonadotrophic potency was unaffected in response to these drugs during postspawning phase.

Assessment of thyroid activity in response to clomid, sezovid, PGE_1 and $PGF_{2\alpha}$ in *H. fossiis* was done by measuring ^{131}I uptake and conversion ratio (CR). Except $PFG_{2\alpha}$, all these drugs failed to influence thyroidal activity during postspawning period. However, clomid, sexovid and $PGF_{2\alpha}$ induced thyroidal ^{131}I uptake and conversion ratio during preparatory phase. PGE_1 administration augmented only thyroidal ^{131}I uptake but failed to influence CR during preparatory phase. None of the above drugs were capable of affecting thyroidal activity in hypophysectomized specimens of *H. fossilis* either during preparatory or postspawning period. Only $PGF_{2\alpha}$ was affective in inducting serum thyrotrophic potency without affecting its level in pituitary during postspawning phase but not during preparatory phase. Pituitary as well as serum thyrotrophic potency were not affected by clomid, sexovid and PGE_1 during any phase.

Hepatosomatic index was unaffected in either of the phase in response to clomoid, sexovid, PGF_1 and $PGF_{2\alpha}$. Total lipid concentration in ovary had increased in respouse to all these drugs during preparatory phase. Ovarian lipid decreased after the administration of sevovid and PGE_1 but was unaffected in response to clomid and $PGF_{2\alpha}$ treatment during postspawning period. Total and free cholesterol levels in ovary were affected neither during preparatory nor postspawning phase. All drugs except $PGF_{2\alpha}$ were capable of increasing ovarian esterified cholesterol level during preparatory phase but were ineffective during postspawning period. Liver lipid concentration had decreased in response to clomid and PGE_1 treatments but increased after sexovid administration during preparatory phase. During postspawning period sexovid and PGE_1 treatments reduced liver lipid when clomid was ineffective. Administration of $PGF_{2\alpha}$ could not influence liver lipid in any phase. Concentration of total cholesterol in liver decreased iu response to $PGF_{2\alpha}$ and sexovid administration during preparatory phase and increased after sexovid

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treatment during postspawning period. Other drugs were ineffective in these phases. Changes in free cholesterol in response to these drugs were similar to that of total cholesterol during both the phases. Esterified cholesterol level in liver decreased in $PGF_{2\alpha}$ treated fish during preparatory phase but other drugs could not bring any change in its level in any phase. Total, free and esterified cholesterol levels of serum were unaffected in response to clomid, PGE_1 and $PGF_{2\alpha}$ during both the phases. Sexovid elevated total, free and esterified cholesterol levels in serum during postspawning phase but nor during preparatory phase.

All these drugs were capable of reducing serum sodium level during preparatory phase but only clomid was effective during postspawning period. Sexovid and PGE_1 were effective in increasing serum potassium during preparatory phase wheras other drugs were ineffective. Clomid and sexovid reduced serum potassium but PGE_1 increased it during postspawning period. $PGF_{2\alpha}$ was ineffective during both the phases. All these drugs failed to affect the levels of calcium, protein phosphorus and lipid phosphorus in serum during postspawning period but they elevated serum protein phosphorus during preparatory phase. An increase in serum calcium in response to clomid and sexovid and in lipid phosphorus in clomid, sezovid and PGE_1 treated fish was observed during preparatory phase.

It seems that these drugs are more effective during preparatory than postspawning phase in inducing gonadal and thyroidal activities and gonadotrophic potency in *H. fossilis* but their effect on biochemical parameters are not consistent.

EODOCRINE CONTROL OF OXIDATIVE METABOLISM IN INDIAN GARDEN LIZARD *Calotes versicolor*

Braj Bansh Prasad Gupta Sup : *Dr. J. P. Thapaliyal*

In homeotherms endocrine regulation of oxidative metabolism has been extensively studied. However, so far no attempt has been made to study in detail the involvement of hormones in the control of metabolic rate of poikilothermic vertebrates. The phylogentic importance of reptiles, lack of detailed information on endocrine control of oxidative metabolism and our interest in reptilian physiology, encouraged us to undertake a comprehensive study of endocrine regula-

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tion of energy metabolism (in term of whole body oxygen consumption and tissues respiration) of a lizard *(Calotes versicolor)* that is locally available all round the year. Therefore, experiments were planned to investigate the relative roles of thyroidal and gonadal hormones during all months of the year and of the adrenal hormones (adrenaline and corticosterone) during the four phases of the annual activity cycle i. e., hibernation, post-hibernation, breeding and pre-hibernation. In all the experiments lizards were fully exposed to natural environmental factors.

The present dissertation has been divided into five sections.

Section I—Seasonal variations in oxidative metabolism of *Calotes versicolor*

(i) Rate of whole body oxygen consumption and of liver, muscle, kidney, brain of the lizard exhibited an annual pattern of variations.

(ii) Different tissues showed different patterns of annual/seasonal variations in their metabolic rate.

(iii) Metabolic rate of the lizard was minimum during hibernation and maximum during breeding phase.

(iv) Statistically significant circannual rhythms were detected in rate of oxygen consumption by whole body, liver, muscle and kidney.

(v) In *Calotes versicolor* circannual rhythms of reproduction and of metabolic rate of whole body, liver and muscle appear to be tightly synchronized.

(vi) Statistically significant circannual rhythm in kidney O_2 uptake is probably associated with hibernation and arousal.

(vii) Significant circannual rhythm in brain O_2 uptake was not recorded suggesting that brain metabolic rate is independent of cycling environmental factors, both external and internal.

(viii) Gonadal steroids and catecholamine(s) may be more important for energy production during hibernation and at the time of arousal.

(ix) Higher levels of thyroidal and gonadal hormones probably control the higher metabolic rates of the lizard from April to August (gonadally active phase).

(x) Transient increases in brain O_2 uptake during November, February and May probably lead to initiation and end of hibernation and beginning of breeding phase.

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(xi) Different patterns of annual variations in rate of respiration of tissues probably suggest involvement of different hormones and/or hormonal combinations in the control of metabolic rates of different tissues during different phases of annual activity cycle.

Section II—Effect of l-thyroxine and male hormone on oxidative metabolism of intact *Calotes versicolor*

(i) Administration of l-thyroxine induced significant increase in oxygen consumption of whole body, liver, muscle and kidney during March to November, April to August, February to November and June to September, respectively.

(ii) l-Thyroxine caused significant increase in brain tissue O_2 uptake first in March-April and again during July to September periods.

(iii) Testosterone stimulated rate of oxygen consumption of whole body and of liver significantly first during January and then during October to December period.

(iv) The rate of muscle O_2 uptake was stimulated significantly by testosterone during January, November and December only.

(v) Testosterone stimulated kidney O_2 uptake significantly during all the months.

(vi) Brain O_2 uptake was increased significantly during July-August period and decreased during February and May following testosterone treatment.

(vii) l-Thyroxine could stimulate oxygen consumption of the lizard even at low temperatures (20°C or low) suggestiug behavioural thermoregulation.

(viii) Annual sensitivity rhythm of differeut tissues to different harmones is different and is controlled by different factor(s).

(ix) Annual sensitivity rhythm of liver to l-T_4 and male hormone is independent of ambient temperatures.

(x) Availability of receptors to exogenous hormones may be involved in the sensitivity rhythm of tissues.

(xi) Temporal relations among different endocrine glands may also be involved in the control of tissue sensitivity rhythms.

(xii) The physiological actions of harmones are dependent not only on the availability of the hormones but are influenced by the sensitivity of target tissues also.

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(xiii) Male hormone stimulated oxidative metabolism of the lizard even during winter months when l–T_4 was ineffective.

(xiv) Gonadal hormones probably help the animal in reproduction during spring and summer and in energy production during winter when ambient temperatures are low.

(xv) Male hormone seems more important than thyroid hormone in the control of metabolic rate of kidney.

(xvi) Kidney metabolic rate appears to be sensitive to male hormone throughout the year.

(xvii) Depending upon the month/season of the year, testosterone may stimulate, inhibit or produce no effect on brain O_2 uptake.

Section III—Role of l–thyroxine and male hormone in oxidative metabolism of thyroidect omized *Calotes versicolor*

(i) Thyroidectomy resulted in significant decrease in the rate of oxygen consumption of whole body, liver, muscle, kidney and brain of *calotes* during February to October, March to October, February to November, February to June and February to May periods, respectively.

(ii) The decline in the rate of oxygen consumption of whole body, liver, muscle, kidney and brain following thyroidectomy was inhibited by l-T_4 administration during all months except of kidney during February and of brain during May.

(iii) Male hormone administration inhibited the decline in the rate of oxygen consumption of whole body, liver, muscle and kidney of thyroidectomized lizards during all months, but was effective on brain O_2 uptake during February only.

(iv) Effect of thyroidectomy on oxidative metabolism is independent of ambient temperatur es.

(v) Thyroidectomy effected differently not only the rate of respiration of different tissues and also of the same tissue during different months.

(vi) Decrease in metabolic rate of the lizard following thyroidectomy is probably brought about not only due to decreased level of thyroid hormone(s) but also due to inactivation of the gonads.

(vii) Male hormone and l-T_4 were able to reverse thyroidectomy effect on oxidative metabolism of *Calotes*.

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(viii) In general, male hormone and l-T_4 appeared to be equally potent in reversing the ill effect of thyroidectomy on metabolic rate of the lizard.

(ix) Decrease in the rate of kidney O_2 uptake following thyroidectomy was probably brought about by inactivation of gonads.

(x) Male hormone stimulated oxygen consumption of whole body and of different tissues even in the absence of thyroid gland.

(xi) Thyroidectomy probably alters sensitivity to the tissues to thyroidal and to gonadal hormones.

Section IV—Role of male hormone and l-thyroxine in oxidative metabolism of orchidectomized *Calotes versicolor*

(i) Castration caused significant decrease in the rate of respiration of muscle and of kidney from February to September and February to November, respectively, the rates of oxygen consumption of whole body, liver and brain also decreased from February to May.

(ii) Administration of male hormone always reversed the depressive effect of castration.

(iii) l–Thyroxine inhibited the decline in the rate of respiration of whole body and of tissues following castration except of liver during June-July and of kidney during February, March and November.

(iv) In castrated lizards l–T_4 induced significant increase in the rate of oxygen consumption of whole body, liver, muscle and brain during June to October, August to October, January and October and June/July periods, respectively.

(v) Gonadal hormones appear to be directly involved in control of oxidative metabolism of the lizard.

(vi) Depending upon the phase of activity cycle and tissue, castration decreased or produced no effect on the rate of respiration of tissues.

(vii) Reduced rate of respiration of whole body and of different tissues following orchidectomy could also be due to decreased thyroid activity, especially during post-hibernation phase.

(viii) Male hormone and l–T_4 were equally potent in reversing the ill effect of orchidectomy on oxidative metabolism of the lizard.

(ix) Orchidectomy probably changes the sensitivity of tissues to thyroidal and to gonadal hormones.

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(x) Internal level of gonadal hormones and availability of receptors may influence tissue sensitivity to hormones.

(xi) Kidney O_2 uptake is controlled mainly by gonadal hormones.

(xii) Muscle metabolic rate is controlled both by thyroidal and gonadal hormones during post-hibernation to pre-hibernation period.

(xiii) While metabolic rate of the lizard during post-hibernation period is controlled jointly by thyroidal and gonadal hormones, during breeding phase thyroid alone seemed to control energy production.

Section V—Adrenal hormones and oxidative metabolism of *Calotes versicolor*

(i) Adrenaline increased O_2 uptake of whole animal and of different tissues of intact lizards during all the phases of annual activity cycle.

(ii) In breeding phase, thyroid hormone(s) is a pre-requisite for calorigenic action of adrenaline on muscle, kidney and brain.

(iii) Effect of adrenaline on oxidative metabolism of *Calotes* is independent of ambient temperatures.

(iv) The degree of response of different tissues to adrenaline was not the same during all the phases of the activity cycle.

(v) Corticosterone does not appear to have significant effect on whole body oxygen consumption.

(vi) Depending on the month/season, presence and absence of thyroid and specific tissue, corticosterone stimulated inhibted or produced no effect on the rate of oxogen consumption.

After extesive analyses and correlations of results recorded in the five sections it has been concluded that :

(i) Metabolic rate of *Calotes* versicolor is maximum during breeding and minimum during hibernation.

(ii) Different tissues differ in their enegy requirements during different phases of the annual activity cycle.

(iii) Different tissues have evolved different annual rhythm of sensitivity to different hormones.

(iv) Internal factors (hormones and/or hormonal combinations) are more important than enviromental factors in the control of annual sensitivity rhythm of different tissues to different hormones.

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(v) Effect of thyroidal, gonadal and adrenal hormones on oxidative metabolism is independent of ambient temperatures.

(vi) Gonadal hormones are equally (if not more) important than thyroidal hormone(s) in the regulation of energy metabolism.

(vii) Adrenaline can stimulate oxygen consumption of the lizard irrespective of the month/season of the year.

(viii) Metabolic rates of whole body and of different tissues are controlled by different hormone(s) and/or hormonal combination(s) during different phases of annual activity cycle.

STUDIES ON SOME ASPECTS OF ECOLOGY AND HOST-PLANT RELATIONSHIP OF *Epilachna vigintioctopunctata* FABRICIUS (COLEOPTERA)

Indu Mohan Sup : *Dr G. P. Agrawal*

The thesis entitled "Studies on some aspects of Ecology and Host-plant relationship of *Epilachna vigintioctopunctata* Fabricius (Coleoptera)" includes some vulnerable informations pertaining to ecological aspects such as biology, seasonal population build-up and population dynamics of the beetle in relation to *Solanum melongena* plant and aspects of host-plant relationship of the beetle with reference to economically important solanaceous plants, which were mainly attacked by the adults and grubs of this beetle.

In economic entomology, a knowledge of specific or highly preferred host(s) is considered to be essential for developing an effective strategy for pest management and integrated pest control. The ability of concerned insects to breed on a variety of host plants, their fecundity, comparative growth rate during post-embryonic development, the nutritional behaviour, the biology and population dynamics are essential features in our understanding to the degree of host-specificity, which will determine the status of the pest. Therefore, the present study was conducted.

Epilachna vigintioctopunctata causes severe damage, mainly to cultivated and wildy growing solanaceous plants. Its infestation is relatively higher on potato, brinjal and tomato crops beside these some medicinal plants such as Dhatura, Asgandh, Makoi etc. are also damaged by these beetles. The ecological studies have been performed in the field while aspects of host-plant relationship were studied

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in the laboratory. The experiments were conducted under similar conditions of temperature and relative humidity. The grubs used in the experiments were fed on thoroughly mixed leaf-pieces of all the experimental plants and feeding of the grubs on leaf pieces of any particular tested plant was avoided as it could induce liking or preference for that particular plant. The grubs used in the experiment were drawn from the third generation of the culture maintained in the laboratory.

In all, a total number of 15 plant species of family Solanaceae, representatives from vegetables, medicinal, narcotic and ornamental plants were selected as test plants which were grown in the experimental pots maintained in the department of Zoology and in Agricultural farm of Banaras Hindu University.

This study was conducted under two parts :

A. Ecological studies pertaining to (i) biology and behaviour and (ii) seasonal population build-up and population dynamics.

B. Host-plant relationship pertaining to (i) attractivity (ii) plant acceptance and feeding response, (iii) suitability of food plants for growth, development, nutrition and reproduction, and (iv) adult orientational behaviour in response to host and non-host plant, visual stimulus, humidity and odour.

The biology of the beetle was studied in the field with the help of two experiments, first experiment was designed to record larval survival, larval and pupal periods, emergence percentage, sex ratio and morphological features (i. e. size and colour changes) of groups, pupae and adults. The second experiment was designed to study the reproductive performance of the female beetle with respect to oviposition period, fecundity and hatchability of the eggs.

The population studies were conducted in brinjal field of Agricultural farm of Banaras Hindu University. The sampling was done during different months of the year 1981, and the population of different stages (eggs, grubs, pupae, adults) were computed on hectare basis; the effect of temperature and relative humidity (abiotic or density independent factors) was determined on the population of the beetles.

The attractivity of the grubs with respect to different plants was adjudged on the basis of responses of the first, second, third and fourth instar grubs towards them. Plant acceptance and feeding response was judged by using unstarved and starved fourth instar grubs.

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The comparative suitability of the tested plants was determined on the basis of their support for the growth (in terms of weight gained by the grub, pre-pupa, pupa and adult), development (larval growth index, pupal index, emergence, sex ratio and longevity), nutrition (the ingestion, digestion and various indices such as approximate digestibility (A. D.), consumption index (C. I.), efficiency of conversion of ingested food into body matter (E. C. I.), efficiency of conversion of digested food into body matter (E. C. D.), coefficient of metabolism (Qm. D.) and growth rate (G. R.) and reproduction (reproductive durations, fecundity, viability and incubation period).

The orientational response of the adult beetle in respect to host plants, non-host plant, visual stimulus, humidity and odour(s) was also studied.

Results obtained from the experiments were analysed statistically by using chi-square test (x^2), analysis of variance (F), coefficient of correlation (r) and critical ratio test.

The results have been summarised and discussed under two main headings :

A. Ecological studies

1. Biology and behaviour : The grub moulted thrice to have four instars. The duration of first, second, third and fourth instars was 2-3, 3-3.5, 3-4 and 3-4.5 days, respectivaly. Pre-pupal and pupal stage lasted for 1 and 2-3 days, respectively. Female beetles survived for a longer period than the male. Mating occurred on third day after emergence. It was preceded by a calling action of female; which consisted of raising and lowering of antennae and elytra. On the approach of a male, the raising of abdomen by female indicated their willingness for mating. Pre-oviposition period varied from 2-3 days. The oviposition takes place in two phases and the period ranged from 6-9 days. Eggs were laid in batches, in a batch the number varied from 25-60. The total number of eggs laid by a female varied from 272-310. Incubation period lasted for 2 days. Hatching percentage ranged between 88.25%--95.20%. On brinjal leaves the larval survival and adult emergence were 87.77% and 93.67%, respectively; male and female sex ratio was 1 : 1.55.
2. Seasonal population build-up and population dynamics : The population of the beetle showed fluctuations above and below the mean population level during different months. The months

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of July, August, September, February and March were favourable for the population build-up, as the population during these months was above mean population level. However, the months of October, November, December, January, April, May and June were not favourable for the population build-up as the population was below the mean population level. The population showed two annual peaks, one during the month of August and another during the month of February. In the months of December and January the population was very low and represented by few hibernating adults only, similarly in the month of June the population was very low, represented by aestivating adults. As the temperature and humidity differed during different months of the year, it was expected that these climatic changes may affect the size of the population but it was observed that the population size neither depended on prevailing temperature nor on the prevailing relative humidity. However, it was evident that the highest peak occurred at 27.33°C and 80.38% relative humidity in the month of August and the other peak, smaller to this, occurred in the month of February at 17.51°C and 63.78% relative humidity.

B. Host-plant relationship

1. Attractivity : Four experiments were conducted to find out relative attractiveness of the grubs towards the tested food plants. Out of 15 tested plants, 10 plants were preferred by first two instars and only 9 plants by last two instars. *Datura fastonsa* plant was although least attractive to first two instars, was ultimately found to be unattractive to third and fourth instars. The plants *Physalis peruviana, Petunia alba, Nicotiana plumbaginifolia, Nicotiana rustica, Nicotiana tabacum* were not found to be attracfive to any larval instars. Ail instars showed their maximum attractiveness towards *Solanum melongena.* The fact, that the just hatched grubs the beetle were competent like that of third and fourth instars in selecting the food plants, suggests that the olfaction behaviour in these grubs is inherited and retained throughout the larval period in an almost constant manner.

2. Plant acceptance and feeding response : Four experiments were conducted to judge plant acceptance and feeding response by fourth instar, unstarved and starved grubs. Out of 15 plants only 9 were accepted by the unstarved fourth instar grubs at different durations, these accepted plants also elicited the feeding

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response. In starved condition, out of 7 tested plants, only 3 were accepted by starved fourth instar grubs at different durations and also elicited the feeding response. The most readily and greedily acceptable plants were *Lycopersicum esculentum, Solanum melongena, Solanum tuberosum* and the least acceptable palatable plant was *D. alba* for the unstarved fourth instar grubs. In starved condition *D. alba* plant was moderately acceptable and palatable and plants *D. fastonsa, P. peruviana* were least acceptable and palatable.

The results pertaining to attractivity, plant acceptance and feeding response indicated that in addition to last two instars, the first two instars were also able to discriminate between the host and non-host plant, this shows that the accepted plants contain some attractant(s) and feeding stimulant(s) and the variation in feeding might be due to varying concentrations of these attractants and feeding stimulants. The results also indicated that the unstarved fourth instar grubs accepted only attractive plants for feeding. Likewise the starved fourth instar grubs also accepted only attractive plants for feeding. These facts suggest that the factors which elicite the feeding and that which attract the grubs are related.

3. Suitability of food plants

(a) Growth : The over all growth of the grub, pre-pupa, pupa and adult varied in relation to the tested plants. *S. melongena* had the highest growth supporting potential as the weight gained by the grub (36.75 mg), pre-pupa (34.25 mg), pupa (26.75 mg), male beetle (22.25 mg) and female beetle (26.18 mg), was the highest in contrast to *D. alba* which had the lowest growth potential, as the weight gained by grub (18.40 mg), pre-pupa (16.10 mg), pupa (14.70 mg), male beetle (10.80 mg) and female beetle (14.10 mg), was the lowest. In all cases the females produced were heavier than the males. This suggests that the differences in growth supporting capacity of tested plants were mostly due to differences in nutritive value of the tested plants, which was governed by the primary as well as the secondary plant substances.

(b) Development : None of the tested plant species induced cent-percent larvel survival. It was the maximum (93.33%) on *S. melongena* plant and the minimum (60.0%) on *D. alba* plant. The larval period was the longest (21.12 days) on *D. alba* and shortest (11.91 days) on *S. melongena*; the pupal period also varied, longest (6.08 days) on *D. alba* and shortest (2.70 days)

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on *S. melongena.* The percentage of emergence also varied, *S. melongena* plant was found inducing the maximum (94.40%) emergence and *D. alba* plant the minimum (38.40%) emergence. Most of the tested plant species resulted in producing more females than males except *D. alba, P. ixocarba,* S. *xanthocarpum* and *W. samnifera.* The larval growth index was highest (7.83) on *S. melongena* and lowest (2.84) on *D. alba* plant reared grubs. The pupal index was the maximum (6.45) on *S. melongena* and minimum (1.41) on *D. alba* plant reared grubs. The male and female beetles raised on *S. melongena* plant survived for the longest duration in comparison to the beetles raised on other plant species. These results suggest that on best suitable host plant, the development was quickest and the insect build-up its population by better survival and emergence of female beetles.

(c) Nutrition : The quantity of food ingested, digested by a grub and various indices of consumption and utiiization varied in relation to tested food plants. *S. melongena* plant leaves were consumed in the maximum (173.97 mg) and of *D. alba* in the minimum (109.75 mg) quantity by a grub. The plant, *L. esculentum* had the maximum (70.95%) and *W. samnifera* the minimum (34.67%) A. D. values. The C. I. was the maximum (0.93) on *S. tuberosum* plant and the minimum (0.54) on *D. alba* plant. The E. C. I. was maximum (20.54%) on *S. melongena* plant and the minimum (13.16%) on *S, xanthocarpum* plant. The E. C. D. was the maximum (44.08%) on *W. samnifera* plant and the minimum (24.30%) on *S. xanthocarpum* plant. The Qm. D. value was the maximum (75.69%) on *S. xanthocarpum* plant and the minimum (55.91%) on *W. samnifera* plant. The G. R. was the maximum (0.16) on *S. melongena* plant and the minimum (0.08) on *D. alba* plant. These variable results suggested that tested plants differ in their nutritive values.

(d) Reproduction : The fecundity of the beetles raised on different plant species also varied. The beetle raised on plant *S. melongena* laid the maximum number (310) of eggs and that raised on plant *D. alba* laid the minimum number (124) of eggs. The hatchability of the eggs also varied from 90.00-23.30%, the female raised on plant *S. melongena* produced the maximum number of viable eggs than that raised on *D. alba* plant. This suggests that the variation in oviposition preference and fertility was due to some plant chemicals present in the tested plants.

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4. Orientation : Beetles orientational response to all the tested plants due to attraction appeared to be equally high and the attraction was due to their visual stimulus, humidity and odour. The arrival of the beetle was maximum (93.33%) on *S. melongena* plant and minimum (74.00%) on *D. alba* plant. Beetles were also attracted towards the non-host plant but did not settle on it. The visual stimulus (green colour) of both host and non-host plant was attractive. Beetles also got attracted towards the humidity stimulus. The maximum arrival of the beetles occurred on methanol extract of both host and non-host plant leaves. This indicated that both host and non-host plant leaves had some attractant(s) but beetles repulsion from the non-host plant leaves proved the presence of some repellent(s) on it.

ROLE OF THYROID IN REPRODUCTION OF MIGRATORY REDHEADED BUNTING, *Emberiza bruniceps*

Pardeshi Lal Sup. : *Dr. J. P. Thapaliyal*

Role of thyroid in the regulation of annual ganadal and body weight cycles of a migratory bird has been examined in detail. Birds exposed to normal daylength (NDL) and to 15L:9D were thyroidectomized every month of the year and alterations in gonad sized and activity and body weight examined over a period of many months. Simultaneously, alterations in gonads and body weight of intact birds maintained under NDL or 15L:9D were also studied.

The influence of L-T_4 was examined under four phases of the annual gonad development and body weight cycles of intact and thyroidectomized birds exposed to NDL or 15L:9D.

Experiments were also conducted to determine the nature of metabolic and gonadal photorefractory states and the causes that induce these states. The role of thyroid activity and photoperiod with special reference to onset and termination of metabolic and gonadal refractory states has also been examined.

Lastly, the influence of prolactin (PR), testosterone (T) and thyroxine (T_4) separataly and in different combinations and also of PMSG alone on the body weight, gonads and gonoducts of photorefractory bunting has been examined.

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Results show that :

(1) Testes of migratory redheaded bunting, *Emberiza bruniceps* start developing during March/April (daylength 11 hrs 56 min) : continue to grow through April, are maximally developed during May/June and then start regressing reaching a minimum by September.

(2) Excepting during mid-May to mid-July period when euthyroidic birds experienced higher growth, there was no significant difference in size and activity of testes of intacts and thyroidectomized birds. Obviously, although the amplitude was significantly less, thyroidectomized birds also experienced a gonad-development cycle which was similar to the cycle of intact birds.

(3) Regardless of the time (month) of operation gonads of birds thyroidectomized during November to March period developed upto April almost at a rate similar to those of intact birds. But during late April to late May period thyroidectomy suppressed gonadal growth significantly. While partial growth of testes occured over the next month when thyroidectomized during late April, regression followed thyroidectomy if performed during mid-May (late progressive phase). Extirpation of thyroid during breeding phase had no significant effect on testis size and activity.

The cytology of partially developed testes of thyroidectomized birds during May revealed the presence of secondary spermatocytes as the most advanced cell type.

Thus in the absence of thyroids gonads experienced a cycle of low amplitude in which only secondary spermatocytes were formed. Intacts, on the other hand, exhibited normal growth cycle with a peak during May-June.

(4) Results of L–thyroxine injection experiments suggest that, except during mid-May when thyroidectomy led to immediate regression and L–T_4 at 500 ng/bird/day or higher levels counteracted the effects of thyroidectomy on gonads fully during rest of the periods alterations in thyroid hormone levels had no significant effect on increase and decrease of the gonads.

(5) When intact birds were exposed to constant 15L: 9D photoperiod during November to mid-May period, gonads developed maximally within a month of exposure. However, the duration of active period and the extent of absolute growth of gonads

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depended upon the time of exposure. Gonads remained maximally developed for 3 months, if exposed during December, 2 months when light treatment was started during November, January and Februaiy. Although absolute growth was more when exposed during March to mid-May period, gonads regressed immediately after reaching a peak. It is obvious that gonads of light treated birds regressed because of onset of photorefractory state. Further, since transfer of sexually regressed birds under 15L: 9D photoperiod to 20L: 4D or contiuous light failed elicit response, the nature of photprefractoriness in this birds is absolute'.

(6) Exposure to 15L: 9D photoperiod during late May when gonads were fully developed elicited no response in intact birds. It is, however, interesting that during this phase alteration in thyroid activity was also meaningless in terms of gonadal growth. Obviously, the bird had lost capacity to respond to light.

(7) During June to August period gonads of birds (intact and thyroidectomized) regressed irrespective of the photoperiod or hypo-or hyper thyroidic state. Obviously, maximum daylength (13 hr 34 min) available at Varanasi (Lat. 25° 18'N, Long. 83° 01'E) is sufficient to stimulate the hypothalamo hypophysial-gonadal axis fully and any further increase in daylength has no additional effect. This may be of adaptive significance since the bird covers a very wide range of breeding ground (Baluchistan to West Asia and Europe) where amount of daylength from one place to another may vary to a great extent.

(8) Further, since the bird also does not respond to alterations in thyroid activity, it is obvious that a photo-refractory bird is thyro-refractory also. However, while cession of response to light occured during June, insensitivity to thyroid activity appeared a month earlier. Obviously, thyroid-refractoriness precedes photo-refractoriness.

(9) The hypothalamo-hypophysial-gonadal axis regained partial sensitivity to light in 30%, 60% and 90% of the individuals during August, September and October months respectively, but full response to long days appeared during November only. Interestingly, L-T_4 at a dose level 500 ng/bird/day restored full light response during September. Obviously, higher levels of thyroid hormone(s) than those available in intact birds during September are required for full stimulation of the hypophysial-gonadal axis

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by long photoperiod. Obviously, breeding phase is followed by refractory state when neither light nor thyroxine alone or together can stimulate gonads. This is followed by a phase when gonadal growth may occur by long photoperiod provided birds are injected with relatively highlevels of L-Thyroxine. Finally, during November the bird enters a state when long photoperiod itself induces gonadal growth in intact birds suggesting that probably thyroid also has become sensitive to photoperiod. Thus there is an inherent annual rhythm of response of thyroid to long photoperiod with a low point during June-July-August and high from November to May which interacts with the annual rhythm of sensitivity of the central mechanism(s) to thyroid hormone. The latter rhythm is completely insensitive during June-July and is highly responsive to thyroid activity during November to May.

(10) The body weight of migratory redheaded bunting started increasing during February-March, continued to grow through April, arrived at a peak during May and declined thereafter, first non-significantly and then in a highly significant manner, reaching a minimum during September/October. Again after an increase during November it remained almost at the same level until February.

(11) Thyroidectomy during November to March period first led to slow and insignificant and then rapid and significant decrease in body weight of birds. But, when thyroidectomy was performed during April to June period, rapid and significant decrease in body weight followed.

(12) Results of thyroxine injection experiments suggests that while there is no effect of altered thyroid activity during December-January, 500 ng/bird/day of L–T_4 counteracted the effect of thyroidectomy on body weight during March-April. Lower doses (1.25 ng to 5.0 ng) had no effect on low body weight of thyroidectomized birds but higher levels (1000 ng and 2000 ng) led to a significant gain. Excepting higher doses (1000 ng and 2000 ng) which suppressed body weight growth of intact individuals during March-April, all the other doses employed (1.25 ng-500 ng) increased body weight.

(13) During May while lower doses (1.25 ng–5.00 ng) failed to elevate body weight higher levels raised it to intact levels. In intact birds, however, all doses were superfluous.

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Further, since triodothyroxine (T_3) is maximum in the body fluid of birds during February/March period (Pathak and Chandola, 1982) it seems that during this phase, T_3 facilitates lipid deposition. After March probably increasing levels of T_4 with increasing days promote lipid deposition and absence of thyroid hormone depresses it.

(14) During May-June period while presence of thyroid hormone(s) allowed slow regression in body weight, thyroidectomy led to sharp decrease and L-T_4 elevated it upto intact level. Obviously, during this phase thyroid hormones are needed to have a control over decreasing body weight.

(15) During July onwards alterations in thyroid activity had no effect on decreasing body weight. This indicates that perhaps the neuroendocrine system controlling body weight has become insensitive (thyro-refractory) to thyroid hormones. Further, since transfer of such birds to higher photoperiods caused no rise in body weight, suggest that the nature of metabolic refractory state is 'absolute'. The increase in body weight after October probably suggests that the metabolic machinary had resumed its sensitivity to thyroid hormones.

Thus the influence of alterations in thyroid hormone(s) on body weight of bunting depends upon the time (month) of the year or the metabolic state of the bird when the treatment is provided. During early part of the cycle while thyroid hormones are needed to register increase in body weight in latter half, its presence is a pre-requisite for controlled decrease in the body weight of buntings.

(16) On exposure of birds to constant long photoperiod during November to May while intact birds experienced gain in body weight whose behaviour mimiced the changes in gonad size, thyroidectomized birds lost weight. Further while L-T_4 above 250 ng/bird/day elevated body weight of birds to intact level, levels higher than available endogenously were superfluous. Obviously, optimal levels of thyroid hormone(s) are a pre-requisite to sustain light-induced growth in body weight.

(17) During May-June alteration in photoperiod had no influence on body weight of the bird. This is however, remarkable that birds are also insensitive to hyperthyroidic state. This is probably of much adaptive significance to breeding birds since it ensures protection from low ambient temperature, which the bird probably

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faces (low temperatures and food scarcity) at the breeding grounds.

(18) Further, during July-August period neither long photoperiod nor alteration in thyroid activity brought about any significant effect on the decreasing body weight of birds Obviously during this period the neuroendocrine system regulating body weight is refractory to photoperiod as well to thyroid hormones.

(19) L–T_4 injection experiment during September-October indicated that while sensitivity of the metabolic machinary to light is resumed during November thyroid-refractoriness dissipates during September.

(20) Results also show that neither further increase in photoperiod nor alterations in thyroid activity is able to increase body weight of intact photorefractory bird but treatment with prolactin leads to significant gain in body weight. Prolactin however, was ineffective in hypothyroidic bird. Obviously, while a metabolic refractory state appears due to defective output of prolactin, presence of an optimal level of thyroid hormone is also a pre-requisite for its effect on body weight.

Lastly, it may be suggested that in bunting, while absence of thyroid hormone(s) hastens the onset of steroidal feed-back and thus resulting the onset of a gonadal photo-refractory state at a lower level of gonadal development, its absence renders birds metabolically refractory, practically immediately. It would, therefore, be intersting to look if similar situation also prevails in those species which possess similar thyroid-gonad and thyroid-body weight relationship.

On the basis of present results suggestions have been made for a role of thyroid in timing the body weight and gonad-development cycles with special reference to onset and termination points in other birds also.

CIRCANNUAL RHYTHMS IN SPOTTED MUNIA : WITH SPECIAL REFERENCE TO SEASONAL REPRODUCTION

Dinesh Chandra Bhatt Sup. : *Dr. (Mrs.) Asha Chandola*

The spotted munia, *Lonchura punctulata* is a seasonally breeding, non-migratory passerine waxbill (family Estrildidae) distributed all over the Indian subcontinent. This wild bird feeds mainly upon grass

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seeds and crop-grains. In nature as well as in captivity (latitude 25° 18′ N; longitude 83° 01′E) the gonads of spotted munia begin to develop from July, attain peak of activity by September/October and regress from October to November, Thereafter gonads remain quiescent from December to June. The body weight cycle runs parallel with the reproductive cycle while the food intake cycle is almost inversely related with these two cycles. Under natural conditions gonadal growth in spotted munia occurs soon after summer solstice thus coinciding with the declining daylength. Artificial short days slightly shorter than the shortest daylength and long days longer than the longest daylength at Varanasi have no immediate effect on the gonadal development of this bird. Clearly these responses could not be categorised as typically photoperiodic. When birds were held in continuous illumination (LL; 27 ± 2°C) the reproductive cycle freeruns with a periodicity of about 10 months thus entering breeding progressively earlier in each year. The deviation of the period from exactly one year excludes the possibility that the rhythm was governed by any uncontrolled environmental factor. Therefore, the reproductive cycle of spotted munia may be called truely endogeneous, circannual and self-sustaining. This finding is an unequivocal evidence for circannual reproductive rhythm in any avian species. This bird also exhibits circannuality in some of the features associated with reproduction *viz.*, fattening and feeding pattern.

The breeding and associated cycles of spotted munia may be governed by endogenous circannual rhythms but, still the circannual oscillators by themselves may not be efficient regulators and would eventually require environmental cues to synchronise reproductive and associated cycles with the most fovourable time of the year. In an attempt to study the role of photoperiod as a synchroniser birds were held under artificial annual photocycles of 6 months periodicity. In this schedule two reproductive and two fattening cycles were obtained per year. The phase relationship between the cycle of photoperiod and those of reproduction and fattening was found almost maintained as observed in normal daylength. In another experimental approach in which birds were held in reversed annual photocycle gonadal growth occurred much earlier than that in normal daylength control but birds entered yet another cycle in winter concomitant with declining phase of the simulated cycle (when control birds were sexually quiescent). Clearly the declining phase of the artificial annual photocycle was able to cause unseasonal gonadal growth. This argues for a role of changing daylength in timing reproduction. In the birds held in reverse photocycle a reverse body weight cycle was obtained after a period of

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a month's exposure. The annual variation in daylength at this latitude might thus act as one of the synchronisers of circannual reproductive and body whight cycles of spotted munia. Birds held in constant light-dark regimes either exhibited almost freerunning testicular rhytem e. g. in LD 12:12, LD 15:15 and LD 8:8 where the light-dark ratio was 1:1 or pattern *viz.*, in LD 15:9, LD 13:11, LD 10:14 and LD 8:16 in which the light-dark ratios were unequal. These results also suggest that birds appear to take the cue from the progressive changes in daylength to time reproduction.

There are indications that in spotted munia apart from daylength, variations in food intake/availability may also be involved in the timing of reproductive periodicity. Annual food restriction causes a shift in the gonadal cycle of this bird maintained in normal daylength and continuous illumination. The phase relationship between cycles of reproduction and food intake is almost maintained in LL in birds fed *ad libitum*. Since the elimination of food intake rhythm causes a delay in the reproductive cycle it is suggested that the phase relationship of these two cycles could contribute to time reproduction.

Experiments with Pinealectomised and thyroidectomised birds indicate that the presence of pineal and thyroid glands appear to be involved for the seasonality/circannuality in one parameter or the other.

STUDIES ON REPLICATION IN POLYTENE CHROMOSOMES OF *Drosophila*: REPLICON PROPERTIES AND HORMONAL EFFECTS ON INITIATION OF POLYTENE REPLICATION CYCLES

Pradip Sinha Sup : *Dr. S. C. Lakhotia*

The exquisite banding pattern of polytene chromosomes provides ideal scope for an analysis of the replication cytology of eukaryotic chromosomes. Earlier ^{3}H-thymidine autoradiographic studies on polytene chromosomes have provided extensively detailed information about the temporal pattern of replication in the different chromosomal regions (Rudkin, 1972; Bostock and Sumner, 1977; Mukherjee et al., 1980). However, very little information has been obtained about the control of initiation of the successive rounds of the polytenic DNA synthesis during the course of larval development and the organisation of active replicons in polytene chromosomes. In the present study, these two aspects of DNA synthesis in polytene chromosomes have been studied in larval salivary glands of *Drosophila*

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nasuta. To facilitate these studies, *in vitro* culture conditions for larval salivary glands of *D. nasuta* have also been defined.

In the first Chapter of this thesis, *in vitro* culture conditions under which DNA synthesis in larval salivary glands can be maintained are described. The salivary gland culture medium described by Poels (1972) has been used for the present study with the following modifications. The different amino acids in the original medium have been replaced by lactalbumin hydrolysate and bactopeptone and the medium has been supplemented with insulin. To ascertain optimal culture conditions, salivary glands from mid third instar larvae of *D. nasuta* have been cultured in this medium under the following different conditions : (i) the medium was supplemented with serum; (ii) the salivary glands were cultured individually or in mass; (iii) the medium was preconditioned by *in vitro* culture of larval brain and fat bodies and, (iv) the salivary glands were cultured along with larval fat bodies. Of these various conditions, culture of mid third instar larval salivary glands in presence of larval fat bodies has been found to be well suited for maintenance of polytenic DNA synthesis *in vitro*. The integrity of larval salivary glands is maintained for 3-4 days in this medium. Following ^{3}H-thymidine autoradiography, replicating polytene nuclei have been noted till 72h after *in vitro* culture of larval salivary glands. Typical patterns of polytene chromosome replication as seen *in vivo* in *D. nasuta* (exemplified by the different patterns of ^{3}H-thymidine labelling, the prolonged duration of replication of the puff 2R-48A, the a faster replication of the male X-chromosome and the asynchronous replication of the intranucleolar DNA, Lakhotia and Roy, 1979; Roy and Lakhotia, 1981) have also been seen in the *in vitro* cultured salivary glands. When salivary glands were chronically labelled *in vitro* with ^{3}H-thymidine (2 uCi/ml) for 24h, an increase in the frequency of continuously labelled nuclei was seen. This shows that after the *in vitro* culture, new cycles of polytene chromosome replication are initiated in salivary glands. It has also been seen that the frequencies of replicating nuclei as well as the number of nuclei initiating new cycles of polytene replication following *in vitro* culture are higher in salivary glands explanted from the mid, rather than late third instar larvae. These results thus show that the initiation and progression of polytene chromosome replication takes place in the normal fashion in the *in vitro* cultured salivary glands.

In the second Chapter of this thesis, the roles of juvenile hormone (JH) and ecdysone in initiation of new polytenic DNA synthesis cycles have been analysed. Larval salivary glands cultured *in vitro* in presence of different doses of the JH mimic ZR 515 (3.0 ul, 0.03 ul or 0.0003 ul

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per ml of medium) for various durations (up to 24h) show a higher frequency of replicating nuclei than in control sister glands; those cultured in presence-ecdysterone (2.0 ug or 0.2 ug per ml of medium) do not show any difference from the sister glands cultured without the hormone. When larval salivary glands are chronically labelled with ^{3}H-thymidine up to a period of 24h in the presence or absence of ZR 515 (3.0 ul/ml) or of -ecdysterone (2.0 ug/ml), the ZR 515 treated glands show a higher frequency of continuously labelled nuclei, while the -ecdysterone treated glands do not. This shows that while JH stimulates initiation of new polytene replication cycles, ecdysone probably does not alter the pattern of polytene chromosome replication *in vitro*.

To further confirm the above action of JH, the technique of *in vivo* synchronisation (Achary et al, 1981) of polytene replication by feeding the larvae on medium containing 5-fluorodeoxyuridine (FudR) has been advantageously utilised. When *in vivo* FudR-synchronised salivary gland are cultured *in vitro* in presence of ZR 515 (3.0 ul/ml), within a short period (2-10h) of *in vitro* culture, a higher proportion of polytene nuclei initiate new replication cycles than in the untreated but synchronised glands. During the later periods (20h and 30h) of *in vitro* culture, higher frequencies of discontinuously labelled nuclei are seen in the ZR 515 treated glands. These results thus show that the new cycles of polytene DNA synthesis stimulated by JH progress to the terminal S phase in the normal sequence. It is proposed that this effect of JH on polytene DNA synthesis reflects its role during the normal course of larval development.

In the third Chapter of this thesis results of a DNA fibre autoradiographic study of polytene chromosomes are presented. The replicons active during the early S period have been analysed by DNA fibre autoradiography of the FudR-synchronised larval salivary glands in which most of the replicating nuclei show the interband and continuous type of chromosomal labelling. The replicons active during the late S period have been characterised from the discontinuously (D) patterns labelled chromosomes which are frequently seen in the normally growing third instar larval salivary glands. Results show that two distinct classes of replicons are active in polytene chromosomes. Replicons of one class (Type I) are frequently seen in the normally growing third instar larval salivary glands. Results show that two distinct classes of replicons are active in polytene chromosomes. Replicons of one class (Type I) are longer (average size = 64 um), have a very high rate of fork migration (mean rate = 0.95 um

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min^{-1} fork^{-1}) and generally occur in large tandem clusters often extending over a length of several thousand um long DNA fibre. In contrast, the type II replicons are shorter (average size = 20 um), slow replicating (mean rate = 0.07 um min^{-1} fork^{-1}) and occur in shorter tandem arrays containing only a few closely spaced active replicons. Evidences are also presented to show that the type I replicons are active in early S while the type II are active in late S. Partially lysed polytene chromosomes, where the lateral polytene chromatids show various grades of separation from each other, have also been analysed from these DNA fibre autoradiographic preparations. It is seen that the activation of the origin points in the homologous regions of the multitude of lateral polytene strands is temporally as well as spatially asynchronous. In addition, they also provide evidence for variable levels of polyteny along the length of a chromosome arm. Our results thus show that neither the concept of one band as one replicating unit nor the proposed synchronous activation of the origin points in all lateral strands of a band region (Plaut et al., 1966; Rudkin. 1972) are valid. Based on these observations, a new scheme of polytene chromosome replication is proposed.

STUDIES ON REGENERATION OF KIDNEY

Jai Prakash Narain Sup : *Dr. R. H. Singh*

The present study aims to undertake an investigation on the pattern of regenerative changes in the kidney in certain physiological and pathological states including the evaluation of the influence of certain therapeutic agents on the rate of regenerative changes in the organ. It is further envisaged to discuss the nature of regenerative response in general operating in various parenchymatous organs in the mammalian body.

The kidney is one of tha most vital organs. Besides its complex functions, which are extremely vital to the life process, the kidney presents with an interesting and highly differentiated structure. And as such it appears difficult to handle a biological investigation on the kidney. It would be worthwhile to point out that the kidney is not one single organ in real sense. Each kidney in man consists of the composite collection of about a million independently functioning subunits called 'nephrons'. Hence it will be always questionable whether the present investigation refers to regeneration at nephronal level or at the level of gross kidney as an organ because it has been

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observed that the kidney, inspite of the tremendous regenerative capacity, is incapable of forming newer nephrons as a process of regeneration. Thus apparently the regeneration of kidney refers to regenerative changes at the cellular level and at the gross organ level, not that much at the level of nephrons.

Probably the above is the reason why the kidney inspite of its tremendous regenerative capacity suffers from the dominantly irreversible pathological states. This could also be because of the fact that the kidney being exposed to general metabolic pool of the organism is likely to suffer from a variety of irreversible diseases.

A number of investigations, carried out in the past, have suggested that the renal tubular cells undergo rapid hypertrophy and hyperplasia following injury. The popular experiment with compensatory renal growth with unilateral nephrectomy as studied by various workers has revealed valuable information on the regenerative response of a normal kidney. Unfortunately such experiments have thrown no light on the regenerative behaviour of the diseased kidney. Only a few investigations appear to have been reported on this aspect. Hence the author of this thesis felt it more useful to study the pattern of repair and regeneration of renal tissues in common pathological states as seen in clinical practice. It is felt that the attempts to investigate the regenerative changes in such organs in their specific pathological conditions may prove more revealing and may be of applied value. The present study has been conducted in animals already afflicted with acute tubular necrosis of chemical nature and pyogenic pyelonephritis besides the usual experimental model of compensatory renal growth in uninephrectomized rats.

Another dimension of the present study is the assessment of the role of the therapeutic agents promoting regenerative changes. As would be discussed later the regenerative response in physiological organs like kidney are mostly through physiological mechanisms such as a trigger from increased functional load on the existing functioning tissues. However, the possible scope of the therapeutic measures to promote the regenerative response cannot be denied. It is possible that certain therapeutic agents may accelerate the regenerative response in the tissues. Among such agents certain hormones like 'growth Hormone' and the anabolic steroids, besides a number of natural products, claimed for such an effect in tradition, may be evaluated on scientific parameters to prove their efficacy in this regard. In the present investigation some preliminary attempts have been made in this direction with encouraging results.

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Thus the present study is more of an applied nature launched with the objective of evaluating the pattern of repair and regeneration of kidney in desease states and to assess the influence of few therapeutic agents to promote the regenerative response.

As described in methodology of this thesis the present study has been conducted in young growing albino rats using three experimental models such as (1) compensatory renal growth in uninephrectomized rats, (2 chemically induced acute tubular necrosis and, (3) pyogenic pyelonephritis. The sequence of changes in the above three experimental models at different intervals, over a period of four weeks, has been assessed in terms of histological, cellular and biochemical changes in the renal tissue and the functional status of the kidney. Besides gross histological changes, the pattern of changes in tubular cell size, mitotic index, nucleic acids turnover and collagen : parenchyma ratio were the main parameters for the assessment of renal regeneration.

The contents and important findings of the thesis are summarised below :

(1) The main objective of the present study was to evolve and standardize suitable experimental models of common kidney pathology and the parameters of assessment to study and evaluate the pattern of regenerative and reparative changes in the kidney under physiological and pathological states and also to evaluate the efficacy of certain therapeutic measures in the promotion of renal regeneration.

(2) The current literature on the regeneration of the kidney provides valuable information related to extensive investigations on the basic phenomenon of growth and regeneration. But it appears that a little attention has been paid to the actual problem of kidney regeneration during revival from several pathological states which would be of more clinical value.

(3) A few therapeutic agents have been assessed for their effect and possible scope of application to promote the regenerative response of the kidney.

(4) In the present studies we have adopted three experimental models viz. (i) compensatory renal regeneration following unilateral nephrectomy, (ii) $HgCl_2$ induced tubular necrosis and (iii) staphylococcal pyelonephritis in rat. The regenerative response in kidney in different experimental models was evaluated

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in terms of (a) gross organ changes, (b) histological changes, (c) cellular response in terms of changes in cell size and mitotic index, (d) biochemical studies in terms of changes in collagen : parenchyma ratio, and nucleic acid turnover, (e) functional evaluation.

(5) Compensatory renal growth in kidney was produced by contralateral uninephrectomy. Acute tubular necrosis was produced by mercuric chloride intravenous injection. Experimental pyogenic pyelonephritis was produced by intravenous inoculation of *Staphylococcus aureus*.

(6) It is evident from these studies that following unilateral nephrectomy the remaining contralateral kidney undergoes marked rapid increase in its size and weight. This growth is mostly due to cellular hypertrophy. There were also certain evidences suggesting cellular hyperplasia viz. increased RNA synthesis at certain stages besides increased number of mitotic figures.

(7) The acute tubular necrosis caused by mercuric chloride nephrotoxicity was found to be readily reversible pathology. In this state there was severe tubular cell necrosis but there was no distortion of the general architecture of the kidney and the basement membrane remain intact uninjured which serves as a support for certain surviving cells to regenerate and reform the renal tubules by re-epithelization of the existing basement membrane. A sharp increase in mitotic index and nucleic acid synthesis of kidney tissue may be interpreted as cellular hyperplasia leading to the true regeneration. The functional loss was recovered at later stages.

(8) Infective pyelonephritis condition of kidney was slowly progressive. There were evidences of progressive interstitial fibrosis rather than regenerative repair probably because of diffuse involvement of the whole architecture of the kidney in this condition. Decreased parenchymatous and nucleic acid contents indicated absence of hyperplastic activities.

(9) The experimental animals treated with the indigenous drug Punarnavā *(Boerhavia diffusa* Linn.) invariably showed increased urinary output. Comparatively less connective tissue growth i. e. collagen, was observed in the kidney of the treated group of animals. It also promoted parenchymatous growth, DNA and RNA synthesis and mitotic activity in the regenerating kidney.

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(10) Growth hormone treatment of animals in different experimental models appeared to promote renal regeneration. This treatment enhances the tissue parenchyma and nucleic acids. Mitotic activity was found accelerated following Growth Hormone treatment. In GH treated experimental animals there were also certain evidences suggesting early compensation and recovery of lost renal function.

STUDIES ON MAMMALIAN EPIDIDYMIS

Ashok Agarwal Sup. : *Dr. C. J. Dominic*

Section A

Histological, Histochemical and Biochemical Studies on the Epididymis of some Indian Mammals

The histology and certain aspects of the histochemistry and gross biochemistry of the epididymis were investigated in a number of mammalian species. The initial segment of the caput, caput proper, corpus and cauda epididymides in each species manifested distinct morphological features; however, comparable regions of the epididymis in the different species exhibited variations in morphological structure. In general, the initial segment and the corpus exhibited only limited morphological variations. In some species distinct zonations of the duct were seen in the caput and cauda epididymides.

Even though the bulk of the epithelial cells in the epididymidis belong to the type designated as principal cells, in appearance and proportion of these cells varied somewhat in different regions. The basal cells were relatively few and exhibited marked variations in their distribution in the epithelium. Other cell types were rare. Cells with evident holocrine secretory activity were noticed in the epithelium of the caput of the musk shrew, *Cynopterus sphinx* and *Millardia meltada* and in the corpus of *Rattus rattus*.

The epididymal epithelium was relatively high in the proximal part of the duct, moderately high in the intermediate parts and low in the cauda, whereas the lumen was narrow in the beginning and widened continually throughout the organ. Mitotic activity was low in the epididymal epithelium. In general, the density of epididymal spermatozoa increased from the proximal to the distal regions of the epididymis. Spermiophagy by the epididymal epithelium was seldom noticed.

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Conspicuous regional and species differences in the intensity of accumulation of phospholipids, proteins, glycogen, and acid and alkaline phosphatases were observed in the epididymis. Phsopholipid accumulation was intense in the epithelial cells of the cauda. Accumulation of proteins and glycogen was generally high in the proximal regions of the epididymis. Acid phosphatase activity was generally high in the epithelium of the caput and corpus in all species. In most species the cauda epididymidis exhibited a higher level of alkaline phosphatase activity.

Biochemical investigations on six species, viz. *Suncus murinus, Scotophilus heathi, Herpestes auropunctatus, Rattus rattus* and *Funambulus pennanti,* revealed regional and species variations in the levels of DNA and RNA. In most species the highest levels of proteins was noted in the corpus and the lowest level in the cauda. A gradual increase in sialic acid level was evident from the caput to the cauda. The proximal regions of the epididymis (caput and corpus) exhibited a relatively high concentration of glycogen. Ralatively high levels of phospholipids were seen in the caput epididymidis in most species. The concentration of glycerylphosphorylcholine (GPC) exhibited a significant increase from the caput to the cauda. A high acid phosphatase activity was noted in the caput epididymidis of all species. Alkaline phosphatase activity did not exhibit a uniform pttern of distribution in the epididymis.

The results suggest the existence of profound regional and species differences in the structure and secrtory activity of the mammalian epididymis.

Section B

Effects of vasectomy and certain antifertilty drugs on the epididymis of the Indian palm squirrel, Funambulus pennanti Wroughton.

Bilateral vasectomy induced marked regressive histological changes in all epididymal segments. In unilaterally vasectomized squirrels the regressive changes were confined to the epididymis ipsilateral to the operated vas and were comparable in all essential respects with that seen in the epididymides of bilaterally vasectomized animals. Vasectomy also induced suppression of spermatogenesis and disappearance of spermatozoa from the lumen of the epididymis. The levels of DNA, Protein, GPC and sialic acid in the epididymis of unilaterally and bilaterally vasectomized animals were investigated. The changes in the biochemical constituents of the epididymis in vasectomized animals were neither uniform nor consistent.

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Administration of alpha-chlorohydrin, 8.0 or 15.0 mg/kg body weight, for 7, 14 and 21 days induced dose—and duration—related regressive histological changes in the epididymis. The drug also caused changes in the levels of epididymal DNA, RNA, proteins, sialic acid and glycogen. Epididymal levels of GPC, and acid and alkaline phosphatases did not register any change in α-chlorohydrin treated squirrels. The treatment caused the disappearance of epididymal spermatozoa without suppressing spermatogenesis. The effects of α-chlorohydrin on the epididymis of the palm squirrel were completely reversible following withdrawal of the drug.

Administration of cyproterone acetate (CA), 5.0 or 10.0 mg/kg body weight/day, induced duration-dependent regressive histological changes in the epididymis. The treatment also caused the suppression of spermatogenesis and the consequent disappearance of epididymal spermatozoa. CA treatment also induced significant reduction in the levels of epididymal nucleic acids, sialic acid and GPC. Higher dose of CA also induced significant decrease in protein concentration in the epididymis. By 21 days after drug withdrawal, the epididymal histology and the levels of various constituents returned to pre-treatment stage. The results suggest that CA can inhibit fertility in males only when spermatogenesis is inhibited.

CHROMOSOME ORGANIZATION IN *DROSOPHILA*

Jagat Kumar Roy Sup : *Dr. S. C. Lakhotia*

Organization of mitotic chromosomes in undifferentiated embryonic cells and in brain ganglia of *Drosophila nasuta* larvae has been compared in this study with respect to cell cycle patterns, chromosomal replication, segregation of daughter strands to sister chromatids and with respect to sensitivity of mitotic chromosomes in the two cell types to the condensation inhibitory action of some DNA ligands. In addition, the effects of the DNA ligands on condensation patterns of chromatin in interphase cells in early embryos and in larval and adult brain cells have also been studied.

In the first Chapter, the mitotic cell cycle patterns in early embryonic and larval brain cells of *D. nasuta* have been analyzed by ^{3}H-thymidine autoradiography and by 5-bromodeoxy-uridine-Giemsa-sister chromatid differential (BUdR-Giemsa-SCD) staining. Brain ganglia complexes, either from normally grown late third instar larvae

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("unsynchronized") or from 16h BUdR-fed larvae ("synchronized"), were pulse labelled *in vitro* with ^{3}H-thymidine for 10 min and chased in radio-isotope free medium for durations ranging from 15 min to 24h. Air dry preparations were made after the different chase periods and autoradiographed. The autoradiograms were analyzed to define the cell cycle parameters by the labelled mitoses method. The results reveal that the pattern of cell cycle in larval brain ganglia is unusual and cannot be explained on the basis of conventional cell cycle patterns (Quastler and Sherman, 1959). A high frequency (30 to 50%) of labelled metaphases appear as early as 15 to 30 min of chase and this high frequency of labelled metaphases is retained in all samples upto 24h. Besides, even in the late chase samples a majority of metaphases which are labelled show labelling on both chromatids of chromosomes. The typical second cycle metaphases (i. e. silver grains present on one of the two chromatids of a chromosome) are rare. Since the labelled mitoses curve does not show distinct ascending and descending arms, a determination of the various cell cycle parameters (like G_1, S, G_2, M) cannot be made. Apart from this, the chromosomal replication and daughter strand segregation patterns in brain ganglia cells also present a number of other peculiarities. Of these, the high frequency of exclusive heterochromatin labelling in most of the labelled metaphases in all chase samples is most intriguing. While at early hours of chase, such pattern of chromosomal labelling is expected, the persistence of this pattern till late hours of chase is a significant deviation from the known or expected temporal sequence of eu-and hetarochromatin replication. In some nuclei, while one or more chromosomes of a cell show labelling of both chromatids, the other chromosomes of the same metaphase show labelling of single chromatid only. Moreover, in some cases, the heterochromatin regions show labelling on both chromatids, while single chromatid is labelled in their euchromatin regions or vice-versa.

The results of BUdR-Giemsa-SCD staining in larval brain cells complement the ^{3}H-thymidine labelling data. "Unsynchronized" brain ganglia were labelled with BUdR for 15 min to 20h and the SCD staining patterns of metaphase chromosomes were analyzed. Cells from 3-4h old embryos of *D. nasuta* were also labelled *in vitro* with BUdR for 15 min to 4h periods for an analysis of cell cycle pattern in these undifferentiated cells. The presence of asymmetric A-T rich sequences in the heterochromatin regions of *D. nasuta* (Lakhotia et al, 1979) is expected to permit a clear distinction between metaphases having incorporated BUdR for 0, 1, 2 or 3 cycles. In early embryonic cells, the cell cycle is generally brief since typical second cycle stained

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metaphases are seen within 30 to 60 min labelling period. Except in rare cases, the SCD staining of all chromosomes of a cell in embryonic preparations agree with the types expected in a given cycle. However, the SCD staining patterns seen in the preparations of brain ganglia do not always correspond to the expected types. A high frequency (36%) of metaphases even in 20h BUdR labelled brain ganglia shows no differential staining (0 cycle) a lathough on the basis of ^{3}H-thymidine autoradiography data, a much lower frequency of 0 cycle metaphases would be expected. Among the few that show a differential staining of sister chromatids, a majority (40 to 91%) in all samples correspond to 1 cycle BUdR incorporation (drfferential staining in heterochromatin regions only). Besides, in several cases, in a given cell some chromosomes show staining pattern corresponoing to second cycle while the others show Ist or even 0 cycle staining.

To understand the programme of hetero-and euchromatin replication in brain cells during different stages of larval development, brain ganglia from first, second or third instar larvae were either pulse (15 min) or chronically (24h) labelled *in vitro* with ^{3}H-thymidine. The results reveal that in brain cells of first instar larvae the euchromatin replication is more common but in successive larval instars the heterochromatin replicates more often than euchromatin. In view of earlier (Berendes and Keyl, 1967; Lakhotia and Kumar, 1980) and the present results it appears that the eu- and heterochromatin regions in larval brain cells undergo independent endoreplication cycles, and the endoreplication of hetero- and euchromatin occurs in a programmed manner during larval development.

Since the results of ^{3}H-thymidine autoradiography and UBdR-Giemsa-SCD staining of larval brain metaphases are not generally compatible with those expected in regularly proliferating mitotic cells with unineme chromosomes and since endoreplication cycles also occur in larval brain cells, it is proposed that the mitotic chromosomes in larval brain cells generally attain a polynemic organization from a basic unineme condition in the embryonic cells.

The second Chapter of the thesis deals with the effects of some of the A-T base specific DNA ligands, like Hoechst 33258, distamycin A or netropsin, on condensation of chromosomes of *D. nasuta*. These drugs are known to cause inhibition of condensation in mitotic chromosomes. This effect has been taken as a probe to compare the chromosome organization in the undifferentiated embryonic and differentiated larval brain cells. Embryos or third instar larval brain cells

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of *D. nasuta* were cultured *in vitro* in the presence of Hoechst 33258, distamycin A or netropsin for periods ranging from 2-24h at 24°C. Air dried chromosome preparations were made with or without a colchicine treatment and stained with Giemsa. While in the embryonic preparations nearly all of the Hoechst 33258 treated metaphases show inhibition of condensation especially in heterochromatin regions, in larval brain ganglia this effect is rare. The other two DNA ligands, viz., distamycin A and netropsin, also cause inhibition of condensation of metaphase chromosomes significantly more often in embryonic than in larval brain cells.

Brain ganglia samples treated with distamycin A or netropsin have been exposed to prolonged colchicine treatment (4h or 16h) to generate tetraploids (2nd cycle metaphases). Examination of the tetraploid metaphases reveal that even in these cells which have been exposed to distamycin A for more than one mitotic cycle, the frequency of metaphases showing condensation inhibition remains as low as that in the diploid metaphases.

Analysis of the chromosome condensation patterns in brain ganglia labelled with ^{3}H-thymidine (30 min) and chased (16h) in distamycin A containing medium further shows that the condensation inhibition due to distamycin A treatment is not related to a cell having completed 0, 1 or more cycles in the presence of the drug. The mitotic chromosomes in early embryos and in larval brain thus also differ in their sensitivity to the condensation inhibitory action of the A-T base specific DNA ligands and this difference appears to be related to differences in metaphase chromosome architecture in the two cell types.

An interesting observation was made during this study that exposure of live cells to Hoechst 33258, distamycin A or netropsin when followed by a prefixation hypotonic treatment leads to a greater compaction of the chromocentre in a majority of the treated cells. This un-usual compaction of heterochromatin in interphase cells is termed as supercondensation of chromocentre and is analyzed in the third Chapter of the thesis. Without the prefixation hyptonic treatment the condensation of chromocentre is similar in control and the treated cells. The effect of the A–T base specific DNA ligand+hypotonic treatment on chromocentre condensation is generally comparable in interphase cells from embryos, third instar larval brain and from adult brain although the frequencies of cells showing supercondensed chromocentre, to some extent vary between the three cell types. Interestingly, when such Hoechst 33258+hypotonic treated cells are brought

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back to isotonic culture medium for 1 or 4h, the interphase chromatin resumes its original level of condensation. However, Hoechst 33258 remains bound to nuclei since a second hypotonic exposure restores the supercondensation of chromocentre. On the other hand, a G-C specific DNA ligand, olivomycin, does not cause any such effect. It is suggested that only A–T specific ligands can modify the nucleoprotein interaction in interphase nuclei in a specific way so that hypotonic treatment causes a very rapid but reversible reorganisation of chromatin constituents.

The effect of these ligands on DNA and RNA synthesis has also been studied in relation to the chromocentre supercondensation. It is shown that both the number of replicating cells and the rate of replication are inhibited by drug treatments and this exhibition is more pronunced in cells with supercondensed chromocentre. However, the effect of Hoechst 33258 treatment on RNA synthesis is less extensive : the rate of RNA synthesis in a transcribing nucleus remains unaltered but the number of transcribing nuclei is reduced. These results also show that cells which are active in RNA and/or DNA synthesis, preferentially show the Hoechst 33258 + hypotonic induced supercondensation of chromocentre in interphase cells. It is suggested that the tissue specific differences in the frequencies of cells with supercondensed chromocentre are related to differences in the functional status of the given cell type.

BREEDING BIOLOGY OF THE INDIAN TROPICAL POND TURTLE, *Lissemys punctata granosa* (SCHOEPFF)

Murli Ram Yadav Sup. : *Dr. B. Prasad*

India, a tropical sub-continent, is rich in reptilian fauna comprising about 2,500 species out of 2,600 species of living reptiles. A lot of attention has been paid to study the different biological aspects of lizards and snakes. But the Chelonians have not been given due attention so far. Our knowledge about the biology of turtles of the Asiatic region in general and the Indian particular is insignificant. In the present study, the following aspects of the Indian tropical pond turtle, *Lissemys punctata granosa* have been investigated.

1. Architecture of the male primary and accessory reproductive organs and the seasonal morphological and histological changes undergone in the anterior and posterior epididymes and vas deferens.

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2. Architecture of the female primary and accessory reproductive organs and the seasonal morphological and histological changes undergone by them.
3. The corpus luteum and follicular atresia have been studied.
4. Ecology and reproductive behaviours have been investigated.

Chapter I

The histological components of anterior and posterior epididymes and the vas deferens, and their seasonal morphological and histological changes correlating with the seasonal changes in body and testes weight, have been studied and discussed. It has been observed that both the bodies and testis weight attain peak during August, indicating a clear seasonal cycle. Closely paralleling the activity of testes, the accessory sex organs, the epididymes and vasa deferentia also undergo morphological and histological changes. The epithelial height of anterior and posterior epididymes (with a little variation) and vas deferens decreases while the lumen and tubule diameter increase during progressive and reproductive phases (March-August). These conditions are reversed during regressive and preparatory phases of the sexual cycle (September-February). The migration of spermatozoa from the lumen towards the epithelium and their enmeshing into the muscular layer and finally their dissolution have a common tendency in all the three male accessory reproductive organs viz., (i) anterior epididymis, (ii) posterior epididymis and (iii) vas deferens, irrespective of the sexual phases and seasons. The importance of sperm dissolution has been examined and discussed.

Chapter II

Along with the normal morphology and histology, the seasonal morphological and histological changes in the female primary and accessory reproductive organs correlating with the seasonal changes in body, ovaries and oviducts of *Lissemys punctata granosa* have been studied and discussed.

Both the body and ovaries weight attain peak during the reproductive phase (September-November), indicating a clear seasonal cycle. The ovarian follicles have been classified into four classes on the basis of their size : (i) class-I size follicles = 0.1-2 mm, (ii) class-II size follicles = 2-10 mm, (iii) class-III size follicles = 10-18 mm and (iv) class-IV size follicles = 18-26 mm egg diameter. The female sexual cycle has been concluded on the basis of the number and percentages of these follicles. The highest percentage of class-I size follicles in

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the preparatory phase (March-May), class-II, class-III and class-IV size; and the total number of ovarian follicles in the reproductive phase (September-November) were noticed.

A case of ovo-testis was noticed during the routine histological studies of the ovaries.

The entire oviduct has been divided into five regions : (i) Infundibulum, (ii) Magnum-albumen secreting part, (iii) Isthmushell secreting part (iv) Uterus and (v) Vagina. The seasonal cycle of oviduct has been concluded on the basis of seasonal histological changes occurring in the major five constituents : (i) muscle, (ii) corium, (iii) glandular part, (iv) epithelial lining and (v) lumen size. The infundibulum and magnum showed maximum development during the progressive phase (June-Agust), whereas the isthmus, uterus and vagina showed it in the reproductive phase.

The presence of secretory evidence, empty spaces and epithelial detachment and sloughing have been noticed and discussed. Sperm retention has been associated with the mucosal folds of the isthmus region of the oviduct. The presence and migration of spermatozoa in the glandular part, mucosal folds, epithelium and lumen has been noticed and discussed referentially to the same in respect of other reptiles.

Chapter III

The occurrence, development, regression and their physiological importance of corpus luteum and follicular atresia in the ovary of *Lissemys punctata granosa* have been studied and discussed referentially to other reptiles.

The corpus luteum, present on the external surface of ovary after the ovulation, is an oblong or round and opaque yellowish body measuring 4-6 mm size. The number of corpora lutea exactly corresponds to the number of eggs present in the oviduct or eggs laid. The maximum number of corpora lutes was noticed in the month of November.

Histologically, the corpus luteum is surrounded by theca externa and theca interna. The two types of luteal cells have been differentiated : (i) theca lutein cells and (ii) granulosa lutein cells. The theca lutein cells are less abundant, more conspicuous and richer

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in secretion than the granulosa lutein cells. The corpus luteum gradually regresses and degenerates and is ultimately resorbed within the stroma of the ovary. The blood vessels are absent in the centre of active corpus luteum.

The atretic follicles are found year-long. The developmental process occurring in the follicular atresia is same as that the corpus luteum. The follicles of size class-I and II undergo atresia. No atresia has been observed in size classes III and IV follicles. The destruction of luteal tissue by giant cells through phagocytosis takes place in the atresia. In the follicles undergoing atresia, the degeneration of cells takes place from periphery to centre.

Chapter IV

The ecology and reproductive behaviour of *Lissemys punctata granosa* have been studied and discussed referentially to other turtles and tortoises.

No distinct sexual dimorphism exists in *Lissemys punctata granosa*. It occupies both lentic and lotic; shallow or deep habitat. It is omnivorous in feeding habit. Its diurnal activities increase with rise in temperature and vice versa. The courtship and mating behaviours are displayed through sniffing, pushing, hooking, biting, vocalization, mounting caudal probing and coitus by males, and shell drop, lateral waggle and shell lift by females.

After locating a suitable nesting site, the female digs an egg cavity, like a widened earthen pot, by using its hind feet alternately. It deposits its eggs in loam or silt soil or sand soil according to its habitat. It is an annual breeder and lays single clutch of 7–15 eggs. Each egg is smooth, spherical, hard, brittle and whitish in appearance. Once the eggs are laid, no further parental care is taken.

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CENTRAL MODULATION OF PERIPHERAL INFLAMMATION IN RATS

Neeta Das

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(Dept. of Pharmacology)

The inflammatory response, characterized by the cardinal features of arteriolar dilatation, increased vascular permeability and protein exudation, resulting in local edema and pain, has been extensively investigated. The various chemico-pathological changes involved in inflammation are now largely understood. The possible chemical mediators in inflammation have been identified and their respectiye roles in the inflammatory response are weli elucidated.

Unlike the peripheral influences modulating inflammation, little is known about the role of the central nervous system (CNS) in modulating peripheral inflammation. Indeed, it has been aptly remarked, that paucity of relevant data characterizes the question of possible involvement of the CNS in inflammation.

There are isolated clinical and experimental evidences which indicate that the CNS can modulate peripheral inflammation, without firmly establishing such a role. Certain reports also suggest that peripheral inflammation, in turn, can affect CNS activity, though the information available is very limited.

In view of the sparse information existent, the present study was designed to investigate whether the CNS can modulate local inflammation, and if so, to discern the neuroregulators so involved. Attempts have also been made to investigate the probable mechanism(s) by which central modulation of peripheral inflammation is affected. Furthermore, the effect of peripheral inflammation on central neurotransmitter activity has also been studied.

Studies were conducted on four experimental models of inflammation in adult albino rats of either sex weighing between 120-180g. Carrageenin-induced pedal edema was used as a model of acute inflammation. Croton oil-induced exudation in granuloma pouch was used as a model of sub-acute inflammation. Formalin-induced rat paw arthritis was selected as a model of chemically-induced chronic inflammation and adjuvant arthritis in rats was taken as a model of chronic inflammation having an immunological basis. Out of these four models, carrageenin-induced pedal edema was subjected to detailed studies. Selected experiments were conducted using sub-acute and chronic inflammatory models.

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Chapter I

Carrageenin-Induced Pedal Inflammation

Carrageenin-induced pedal edema in rats was adopted as the experimental model for acute inflammation because of reported reproducibility, sensitivity to anti-inflammatory agents, relative specificity and the widely investigated background of the phlogistic agent.

Carrageening-induced inflammation was short-lasting, peaking at 3-4h, though residual inflammation persisted even after a week. A second injection of the phlogistic agent into the contralateral paw after 6 days of the first injection, elicited similar edema, indicating that the same rat may be used for self-control studies after a week's interval. However, when carrageenin was administered into the contralateral paw after 24h, significant attenuation of inflammation was noted, which was not apparent in bilaterally adrenalectomized rats. Adrenalectomy, *per se*, had an inflammation-promoting effect. The data indicates that the decreased inflammation in rhe contralateral paw may be due to stress-induced adrenal activation caused by the primary inflammation. Intracerebroventricular (icv) cannulation produced slight reduction of the edema, and further reduction was noted after administration of artificial CSF. The attenuated inflammatory response in these rats might be due to stress, and highlights the importance of maintaining appropriate controls in these types of experiments.

a. Effect of reserpine

Central administration of reserpine, a monoamine depletor, accentuated carrageenin-inflammation, indicating a possible role for central monoamines and ACh in the modulation of peripheral inflammation.

b. Role of 5-hydroxytryptamine (5-HT)

(i) Central administration of 5-HT and its precursor, 5-hydroxytryptaphan (5-HTP), attenuated the inflammation, whereas 5, 6-dihydroxytryptamine (DHT), a selective central serotonergic neuronolytic agent and para-chlorophenylalanine (PCPA), a specific 5-HT synthesis inhibitor, produced the contrary effect of inflammation-accentuation. Methysergide, a 5-HT receptor antagonist, however, had a 5-HT-like effect and also fail to inhibit the inflammation—inhibiting effect of 5-HT, indicating that post-synaptic receptor blockade is possibly not involved. Methysergide in known to block central serotonergic presynaptic receptors, and the consequent increase in central serotonergic

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activity may help to explain the apparently paradoxical effect of methysergide.

(ii) Peripheral administration of 6-hydroxydopamine (6-HD), leading to peripheral "chemical" sympathectomy, and bilateral adrenalestomy failed to affect central 5-HT-induced attenuation of the inflammation, indicating that the inflammtion-promoting effect of 5-HT is neither mediated through the sympathetic nervous system nor via activation of the adrenal gland. It has been postulated that the observed anti-inflammatory effect may be due to transmethylated metabolites of 5-HT, generated in the presence af an endogenous MAO inhibitor. Some methylated indoles are known to have significant anti-inflammatory effects.

(iii) Rat brain 5-HT content was initially ($\frac{1}{2}$h) increased, followed by a decrease at 1 h, and normalised by 3 h of carrageeniedema. The primary increase followed by a secondary decrease might be a consequence of an attempt at automodulation by the organism to limit the inflammation by activating inflammation-inhibiting central 5-HT activity, the fall indicating sustained overactivity of these neurons, leading to decline in the steadystate levels of the amine at a later stage. A stress effect may also be possible, though the pattern of 5-HT increases in stress situations has been shown to be quite dissimilar.

c. Role of catecholamines :

(i) Central administration of noradrenaline and 1-dopa, a precursor of catecholamines, but not of dopamine, significantly attenuated carrageenin inflammation. 1-Dopa, administered peripherally with benserazide, a peripheral decarboxylase inhibitor, also induced significant inhibition of inflammation. This treatment was ineffective when given to diethyldithiocarbamate (DDC), a dopamine-β-hydroxlase inhibitor, pretreated rats. Central administration of 6-HD, a specific catecholaminergic neuronolytic agent, had an inflammation-promoting effect, which was not apparent when 6-HD was administered in conjunction with desmethylimipramine (DMI). The latter treatment is known to induce selective degeneration of central dopamine neurons. Peripheral administration of amantidine, which activates central dopamine receptors, was also ineffective. These findings indicate that central noradrenaline, but not dopamine, exerts a modulatory inflammation-attenuating effect. Phentolamine, an alpha-adrenoceptor blocker, produced a noradrenaline-like inhibition of inflammation, on central administration. Propranolol, a beta-adrenoceptor antagonist and haloperidol, a dopamine receptor blocker, had little effect. The inflamma-

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tion-inhibiting action of noradrenaline was not affected by pretreatment with central administration of either phentolamine or propranolol. The apparently paradoxical action of phentolamine has been related to its noradrenergic presynaptic blocking action, which is known to induce activation of central noradrenergic neurons, as was indicated by blockada of phentolamine effect in central 6-HD pretreated rats.

(ii) Peripheral administration of 6-HD, leading to degeneration of peripheral adrenergic neurons, had little effect of its own but significantly antagonized the inflammation-attenuating effect of centrally administered 1-dopa. Bilateral adrenalectomy had a discernible, but insignificant, antagonistic effect. The findings indicate that the integrity of the peripheral adrenergic system, is a prerequisite for the inflammation-modulating effect of central noradrenaline, since peripheral administration of noradrenaline produced significant inhibition of inflammation. The adrenals may have a minor role to play,

(iii) Rat brain noradrenaline, but not dopamine, levels were enhanced at $\frac{1}{2}$ and 1 h following inflammation, normalising by 3h. In the absence of any demonstrable modulating action of dopamine, increased noradrenaline concentrations following inflammation, might be a consequence of attempts at automodulation by the organism. However, stress effect cannot be ruled out.

d. Role of acetylcholine (ACh) :

(i) Central administration of acetylcholine and tremorine, a central cholinomimetic agent, enhanced carrageenin inflammation, whereas hemicholinium, which inhibits ACh synthesis, attenuated the inflammatory response. The findings indicate a pro-inflammatory modulatory influence of central cholinergic neurons. Atropine, a m-cholinolytic agent, did not affect ACh response but produced an ACh-like inflammation-enhancing effect on central administration. It was suggested that this effect is a consequence of presynaptic cholinergic receptor blocking effect of atropine, leading to increased cholinergic activity. This supposition is supported by the absence of atropine effect in hemicholinium pretreated rats.

(ii) Peripheral administration of atropine ethoiodide, quaternary ammonium cholinergic blocking agent having only peripheral action, which had little *per se* effect, significantly inhibited the proinflammatory effect of centrally administered ACh, indicating that the functional integrity of the peripheral cholinergic system is necessary for the observed cental effect of ACh. This was highlighted by the inflammation-enhancing effect of carbachol, administered peripherally.

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(iii) Rat brain ACh levels were not at all affected by carrageenin inflammation. This observation is in keeping with the proposed automodulatory effect exerted by the organism, where attempts would be directed to reduce the inflammatory response, rather than to promote it.

(e) Role of histamine :

Central administration of histamine significantly attenuated carrageenin inflammation, whereas the H_1 receptor antagonist, mepyramine, and cimetidine, a H_2 receptor blocker, promoted the inflammation, though the effect of the latter was evident only at 3-4 h and was statistically insignificant. Though no attempts were made to evaluate the possible mechanism of histamine action, there is ample evidence in literature to suggest that it may be either due to activation of the pituitary-adrenal axis and/or to a facilitatory influence on central sympathetic outflow.

(f) Role of prostaglandins (PGs) :

(i) Central administration of arachidonic acid produced an insignificant increase in carrageenin inflammation, whereas the PG synthesis inhibitors, diclofenac sodium and sodium salicylate markedly inhibited the inflammation, on icv administration. Since, arachidonic acid is known to be an unsatisfactory PG precursor in rat brain, more emphasis was laid on the action of the PG synthesis inhibitors, and a central pro-inflammatory effect of PGs could be conceived. PGs are thought to function as neuromodulators and the observed effect might be due to modulation of catecholaminergic and cholinergic neurons, where decreased and increased activities, respectively, have been reported.

(iii) Carrageenin inflammation significantly increased the rat brain concentrations of PGE_2 and $PGF_{2\alpha}$, an effect also noted in bilaterally adrenalectomized animals. This increase may form an integral part of the proposed automodulatory hypothesis, since PGs are known to modulate central serotonergic activity in this species. However, it is much more likely that the observed increase in brain PGs is due to the stress of inflammation, because the pattern closely follows that reported with restraint stress, and is in keeping with their proposed role as the first mediators of stress.

g. Role of sensory input :

Lignocaine, a local anaesthetic agent, markedly inhibited carrageenin pedal edema when administered behind the affected knee joint. The time course of inhibition closely matched the reported duration of action of the drug. The effect of lignocaine might be thought to

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be due to blockade of neural pathways, stimulation of which is reported to generate an inflammation-sustaining chemical substance which though unidentified, is known to be dissimilar to anyone of the known inflammatory mediators.

Chapter II

Granuloma Pouch

The croton oil granuloma pouch technique in rats was adopted as an experimental prototype of sub-acute inflammation. The volume of the exudate on day-6 after induction of the inflammation, was taken as the index of inflammation. The inflammatory exudate was significantaly less in cannulated controls vis-a-vis uncannulated rats, suggesting that cannulation-induced stress may be responsible for the reduced exudation.

(a) Central administration of reserpine, DHT, 6-HD, alone and in conjunction with DMI, produced slight and insignificant increase in the exudate, whereas hemicholinium and diclofenac sodium produced insignificant diminution.

(b) Peripheral administration of l-dopa (with benserazide), produced some degree of inhibition of the inflammation, when administered prior to, but not when given 48h after induction of inflammation. These findings suggest that central cetecholaminergic activity may have a minor modulatory effect in this sub-acute inflammation, which is not apparent once the inflammation has progressed. An inflammation-inhibitory effect of central 5-HT and pro-inflammatory effects of central ACh and PGs, though suggestive, are doubtful.

(c) Rat brain 5-HT and noradrenaline, but not dopamine, levels were significantly enhanced, when estimated on day-6 of inflammation. While this may be viewed as an attempt at automodulation of the inflammation, these may well be secondary to stress.

The investigations suggest that unlike acute inflammation, the evidence for central modulation of subacute inflammation is less conclusive.

Chapter III

Formalin Arthritis :

Formalin-induced arthritis in rats was adopted an experimental model of non-immunologic chronic inflammation. In view of the findings with sub-acute inflammation, attention was directed to only possible modulatory effect of central catecholamines.

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(a) Pretreatment of rats with l-dopa (in conjunction with benserazide), significantly inhibited the inflammation only during the initial stages (first 3 days). When the same treatment was, however, instituted 3 days after induction of inflammation, it was found to be bereft of any effect whatsoever. The findings suggest that central catecholaminergic (noradrenergic ?) neurons may exert an inhibitory influence over the inflammation during the early stages. Once the inflammation has stabilized, this modulatory influence is aborted.

Chapter IV

Adjuvant Arthritis

Inflammation induced by administration of Freund's complete adjuvant was adopted as the experimental model of immunologic chronic inflammation in rats.

(a) Central administration of reserpine, DHT, 6-HD, hemicholinium and diclofenac sodium failed to effect the inflammation all throughout the period of observation. This indicates that manipulations of central monoamines, ACh and PGs do not affect this immunologic arthritis.

(b) Biochemical investigations show that rat brain 5-HT and noradrenaline, but not dopamine, levels were slightly but significantly enhanced on day-3, and only the concentrations of the latter were increased on day-9. On day-15, the rat brain monoamine concentrations were undifferentiated from those of controls. In the absence of pharmacological evidence for central modulation of adjuvant arthritis, the initial increase in noradrenalinal and 5-HT levels may be due to stress normalising when the stresso assumes a chronic character.

Conclusions

When a central function or behaviour is shown to be modulated by a number of neuroregulators, it is naive to conceive that each transmitter acts independently in an insulated manner within the central nervous system (CNS). This holds true when central modulation of a peripheral event is considered. The CNS regulation of respiration, cardiovascular homestasis and hormonal phenomenon are known to be multitransmitter in nature involving an interplay between several neurotransmitter systems.

The central nervous system works basically on the principle of reflex action. It receives information, integrates them and functions, by modulating the various neuroregulator activities, to the best advantage of the organism. In the present investigations, central

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noradrenergic, tryptaminergic and histaminergic systems were found to have inflammation-suppressing activity, whereas the central cholinergic and prostaglandin systems had pro-inflammatory effects. Automodulation by the inflammatory process has been deemed a distinct possibility. It may be construed that the inflammatory process, in an attempt to return to normalcy, activates those neurotransmitter systems which may limit or retard the process of inflammation. The mechanism by which these neurotransmitter systems are activated are not understood, though the inflammatory stress may play a prominent role. The efferent pathways, which may limit the inflammation, may be the autonomic nervous system or the hypothalamo-pituitary-adrenal axis, though some other ill-understood mechanisms may also be involved.

Neurotransmitter pathways overlap in several brain parts and a single neuron may contain more than one transmitter and several receptor sites. This leads to an interplay between central neurotransmitter systems, which have been best demonstrated between catecholamines, serotonin and acetylcholine, and to some extent between histamine, catecholamines and serotonin. Such an interplay may be possible in central modulation of inflammation as well.

The present investigations also provide corroborative though somewhat tenuous evidence to support the clinical observation that schizophrenics are less likely to suffer from rheumatoid arthritis and other inflammatory conditions.

Though the present investigations conclusively demonstrate central modulation of peripheral inflammation in rats, particularly of the acute type, several pertinent questions remain unanswered. Inflammation is a multimediated phenomenon, in which the different mediators enter the stage and made their exit at the appropriate moment, after playing their respective roles in increasing vascular permeability, attracting leucocytes, producing pain, local edema and necrosis. Some of them act directly and others indirectly by potentiating or releasing other agents. Though much is known about the inflammatory reaction, the final answer to the problem is yet to come. Precisely how central modulation of peripheral inflammation is achieved, at what phase of the inflammatory cycle central neuroregulators are involved and how they affect the local mediators of inflammation, need investigation. It is a well known historical fact that discovery of any new factor or scientific event, instead of closing doors, opens up new lanes to which the old ones converge, amlifying views and landscapes for further studies.

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FISHERY AND BIOLOGY OF NORTH INDIAN FRESHWATER PRAWN, MACROBRACHIUM BIRMANICUM CHOPRAI (TIWARI)

Shree Prakash Sup. : *Dr. G. P. Agrawal*

Introduction

The North Indian freshwater prawn, *Macrobrachium birmanicum choprai* (Tiwari) formed a lucrative fishery in the middle stretch of the Ganga River System in the recent past. However, its present fishery has declined to a considerable extent probably due to the changed environmental and biological factors. In order to compensate for this loss its aquaculture seems to be the only alternative. Before taking up this aspect on experimental, as well as on large scale production, it would be imperative to expound the biological characteristics of the population and its stock availability in nature. It is in this context that this study has been taken up.

Besides an up-to-date critical historical review of literature, a concise description of the genus *Macrobrachium* and its Indian species, characteristic features of *M. birmanicum choprai* and the salient characteristics of the habitat—the middle stretch of Ganga River System, the study has been covered out in two parts, the first encompasses the 'stock assessment and fisheries' and the second 'biological characteristics' of the '*choprai*' prawns. Consequently the first part includes—aspects such as seasonal abundance, length frequency distribution sexratio in commercial catches, distribution of juveniles in time and space and in relation to physico-chemical conditions of the environment and probable factors responsible for the dwindling of '*choprai*' prawn fishery. Whereas the second part includes—morphological variations within the species, diagnostic characters of juveniles, length-weight relationship, length carapace relationship, age and growth, condition factor and relative condition, food and feeding habits, maturation and breeding, incubation and embryonic development and hatching and larval development.

Material and Methods

The studies grouped under the two major divisions, have been done by conducting regular periodic visits to the five selected observation centres between Varanasi and Patna, covering the middle stretch of Ganga River System. Stratified random representative samples of '*choprai*' prawns, from the commercial catches, have been regularly collected for biological study. Collections of water samples and their

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physico-chemical analysis have been done by the methods described in "standard methods for the examination of water, sewage and industrial wastes (APHA, AWWA and WPCF 1971)" and "Methodology on reservoir fisheries investigations in India (Jhingran *et al.* 1969)". The significance of variations and coefficient of correlations have been statistically tested. Morphometric measurements, wherever necessary, have been taken up with the help of fine geometric divider, mm scale and smooth thread in case of larger specimens, and with the help of occular micrometer and optical research microscope in case of larvae. Camera lucida has been used for making the diagrams.

The abundance of '*choprai*' prawn juveniles and plankton, in time and space, has been estimated by the methods described by Jhingran (1975) and Welch (1948), respectively. The significance in morphological variations and diagnostic characters has been tested by 'Chi square' test. The length weight relationship has been calculated by multiple regression analysis and 'Cube law' whereas the age and growth were estimated by Petersen's and Probability plot methods. The seasonal pattern of growth has been estimated by calculating the specific growth. The coefficient of condition ($K = Wx10^5/L^y$) and relative condition ($Kn = W/W$) have been calculated to estimate the condition factor. Food and feeding habit have been studied by calculating Index of preponderance (Natarajan and Jhingran, 1961) and the feeding intensity was estimated by calculating gastro-somatic index ($GSI = gut \times 100/TW$) and condition of feed. Maturation and breeding, incubation and embryonic development, and hatching and larval development have been studied by the methods described by Tembe and Shaikhmahmood (1955), Rajyalakshmi (1962), Baker (1966), Ling (1962), and Fujimura (1970), respectively.

Observations

STOCK ASSESMENT AND FISHERIES

Landing pattern—

The north Indian freshwater prawn *Macrobrachium birmanicum choprai*, constituted 14.46% of the total annual landings of the middle stretch of river Ganga (Varanasi to Patna), during the period 1979-81. March to September constituted the main season of the fishery with the peak generally falling in the month of May-June and August-September. Three distinct seasons have been observed in landing pattern out of which monsoon showed the highest index. The cyclical movements were relatively unimportant. A gradual decline in abun-

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dance of yearly catch from 1979 to 1981 and centre-wise increase in prawn catch in the same year from Varanasi to Patna were wellmarked.

Size and lenth frequency distribution :

Practically the same size range was available in the commercial catches all the year round without much variation. The males showed a bimodal distribution whereas the females exhibited only unimodal distribution. Seven normally distributed size groups were evident among the males and the females. Two breedings in a year have been recorded and the species does not seem to have migratory habits and appears to have fully adapted to the freshwater environment.

Sex ratio in commercial catch

In lower size-groups the females have been observed to have dominated the males, whereas in the higher size groups males dominated the females. During the breeding season females were predominant in the catch. The variation has been found significant statistically. The ratio of males to females during all the months combined were found to be 1:1.4.

Berried females and spawning intensity :

The intensive breeding coincided with the first rains as was evidenced by the large number of females appearing in the commercial catches just prior to rains. The first year class constituted the most predominant group of breeders whereas second year-class and third year-class constituted comparatively low percentage. The individuals, beginning to breed for the first time, have been observed to become berried first. The variation in abundance of berried and non-berried females have been found statistically significant. The size at first maturity appears to be 60.0 mm. A significant correlation have been observed between the abundance of females and juveniles.

Fishery of juveniles :

The observations revealed that May and August were the peak months of juvenile abundance and June was the month when lowest juvenile catch was recorded. December to February was the period characterised by the absence of juveniles leaving aside a few stray specimens. The biomodal pattern of fluctuation indicated two breedings in a year. The monthly percentage frequency of juvenile occurrence showed that smaller size group dominated in March to June, medium size group in July to September and large size groups in October and November.

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Abundance of juveniles in time and space :

The number of prawn juveniles caught at various centres and at different hours with similar mesh size nets showed highly significant differences. The smaller juveniles were observed planktonic in nature, whereas, the larger size groups were capable of movement by their own. In terms of percentage composition the abundance of juveniles progressively increased downstreams. The sampling showed higher abundance of juveniles at early morning and late evening as compared to noon in the surface waters.

Juvenile abundance and physico-chemical factors :

Statistically significant (positive and negative) correlation between the juvenile abundance and various physico-chemical factors have been recorded. The intensity of sunlight and silt load directly affected the juvenile abundance.

Factors influencing prawn fishery :

Overfishing, industrial pollution and non-industrial pollution (caused by town sewage with fecal materials, burning, bathing, washing, floating dead bodies and navigational fleets, barriers and lift irrigation complexes have been observed to have affected the prawn fishery to a great extent.

BIOLOGICAL CHARACTERISTICS

Morphological variations :

On the basis of present study the sub-species *Macrobrachium birmanicum choprai* of the middle stretch of river Ganga has been divided into two varieties and nine sub-varieties having statistically significant variations in certain characters. The detailed diagnostic characters of the two varieties and nine sub-varieties have been presented in the text.

Diagnostic characters of juveniles :

Practically feasible diagnostic characters pertaining to rostrum, second chelated leg, 6th abdominal somite, postero-ventral thorax and second pleopods have been observed useful for the identification of *'choprai'* prawn juveniles.

Length-weight relationship :

The length weight relationship of male, female and juveniles indicated a non-linear relationship in their logarithmic values. The coefficient of correlation obtained from regression equations revealed

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that the regression was determined efficiently in each case. To test the equilibrium constant, analysis of covariance and test of significance were performed showing no significant differences in 'b' values of male, female and juveniles. Fisher's 't' test indicated that the "Cube law" was applicable to this species with modification. The increase in weight was slightly higher than the cube of length.

Condition factor and relative condition :

The observations pin-pointed marked dependance of the index on food, sexual maturity and season. The individual variations of the index values were also dependent to size, recording a gradual increase as the size increased, indicating that as the age advances the species registers good ponderal index. During breeding season the decline in the condition factor was observed for less in males as compared to females. The relative condition was also observed dependent on size groups and season. The indices were similar in respect of whole as well as eviscerated prawns excepting in their magnitude.

Age and Growth :

Length frequency distribution and probability plot analysis methods were used for the estimation of age. The composition of commercial catch appeared to hold individuals ranging between 6-42 months. An average growth rate of 5 to 6 mm per month was recorded and the growth rate was ascertained identical in both the sexes for practical purposes. The growth rate was fastest during summer, low during winter and moderate during monsoon season. Specific growth rate was observed highest in the youngs and subsequently declining with age.

Food and feeding habits

The grading of gut contents, monthwise and size-group-wise, has been done by 'frequency of occurrence' and 'volumetric' methods. The food was comprised of diatoms, green algae, blue-green algae, crustaceans, insects, macrovegetation, dead organic matter, and sand and mud in varying percentage according to size, season and their availability. The diatoms have been recognised as the primary food of juveniles. The composition showed a transition from herbivorous to omnivorous and column dwelling to bottom dwelling habits of juveniles and adults, respectively. A linear relationship between total length intestine/stomach and intestine-stomach have been recorded. Observation under laboratory conditions indicated omnivorous feeding habits prefering animal material against plant material.

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Maturity and fecundity

Organisational pattern of the reproductive organs have been found identical to *M. malcolmsoni*. Six stages of maturity have been recorded in ova-development. The monthly ova-diameter frequency polygon presented polymodal distribution in various size groups. 60.0 mm was observed to be the size at first maturity. The females laid eggs twice in one breeding season. Fecundity—total length/total weight/carapace length relationships have been found linear and the ova were observed maturing in batches.

Breeding and spawning

Courting, mating and breeding could be induced in plastic pools which normally occurred during night at late hours and egg laying took place within 6 hours of breeding. Pre-mating moulting was observed as enevitable phenomenon. The sperms deposited on the ventral thorasic part of the female between thorasic legs and on female opening. The ova passing through the sperm mass became fertilized and got deposited in the brood pouch formed by the pleopods.

Incubation and embryonic development

Incubation and embryonic development in freshwater lasted upto 15 days under laboratory conditions, leading the embryo to I zoeal stage.

Hatching and larval development

Hatching occurred usually at late night or early morning producing innumerable hatchlings at I zoeal stage. Larvae could be reared upto 15 days leading the larvae having developed all the body parts of advanced larvae excepting that of pleopods. The larvae were observed grazing on decayed aquatic vegetation accumulated on the bottom of the aquarium.

Discussion

The observations recorded, have been discussed in reference to various published works mainly on fishery and biology of various economically important freshwater prawns, on global basis. The discussion is followed by a comprehensive list of references.

The study presented in the form of thesis, it is hoped, will serve as foundation for further research on fishery, biology, ecological relationships and behaviour of these fascinating animals.

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SEASONAL METABOLIC STRATEGIES OF BIRDS

Vidhu Bhushan Singh Sup. : *Dr. J. P. Thapliyal*

Present dissertation includes a comparative study of seasonal metabolic strategies, with special reference to lipid metabolism, of two laboratory maintained, differently adapted species, the Redheaded bunting, *Emberiza bruniceps* and the Common myna, *Acridotheres tristis*. Redheaded bunting is a sexually diamorphic, passerine migrant, a regular winter visitor to Indian sub-continent. It arrives in India during September/October, departs for breeding grounds during March/April and breeds during May/June. In laboratory conditions, it exhibits marked liking for carbohydrate rich-paddy grains from November to June but shifts its food preference for protein rich insect food during rest of the year. Common myna, on the other hand, is a sedentary, omnivorous, passerine bird, distributed all over India. It also breeds during May/June.

Parameters used for assessing seasonal metabolic strategies of birds were monthly alterations in weights of body and its constituents (lipid, dry nonlipid and water), concentration of glucose in plasma and glycogen in liver and muscle; total lipid of liver and adipose tissue; FFA, MG, DG, TG, PL and total cholesterol in plasma and liver, and FFA, TG and PL in adipose tissue.

In migratory Redheaded bunting, weights of whole body and lipid, dry nonlipid and water fractions of body varied strictly with season. Increase in body weight during spring migration (March/April) with a maximum during early reproductive phase (late May) and a minimum during autumn months (August, September, October) followed by a moderate gain during October to December and slight decline during December/January were the significant features of body weight cycle of this bird. While lipid alone was responsible for alterations in body weight from March to July, protein and water fractions contributed for changes observed during rest of the year. Availability of carbohydrate rich grains in plenty during spring, scarcity of food at the breeding ground and almost complete absence of seeds during autumnal migration due to monsoon has probably led to the evolution of a body weight cycle in migratory Redheaded bunting showing above characteristics.

In non-migratory Common myna, *Acridotheres tristis*, on the other hand, weights of body and its components, i. e., lipid, dry

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non-lipid and water fluctuated irregularly in a year. Alterations in absolute weight of protein and water contents of body accounted for increase or decrease in weights of bird during different months of the year. Lipid fraction, in contrast played little role. Abundance of adult food all the year round has been suggested for the absence of an annual cycle in body weight and also in the weights of three major components of the body.

Concentrations of glucose in plasma and glycogen in liver and muscle; total lipid in the liver and adipose tissue, FFA, TG and PL in plasma, liver and adipose tissue; DG and total cholesterol in plasma exhibited distinct annual cyclicity in migratory Redheaded bunting. However, MG in plasma and liver, DG and total cholesterol in liver varied inconsistently during the year. Seasonal alterations in levels of above metabolites in different tissues clearly reveal that the process of hyperlipogenesis is initiated during spring premigratory phase (February/March), gains further acceleration while spring migration is in progress, attains a peak during early reproductive phase (late May) resulting in enormous increase in TG levels in liver, plasma and adipose tissue. Interestingly glycogen reserves of liver and muscle also reached maximal concentration during this period. Such metabolic adaptations are probably the consequence of better utilization of carbohydrate rich diet with possible involvement of various lipogenic hormones like prolactin, thyroxine, gonadal steroids and insulin. However, during breeding and post-reproductive phases (from late June to October) lipogenic activity ceases and lipolytic activity is encouraged. Marked reduction in glycogen and lipid reserves of body is a noteworthy feature of this phase. Bad weather and unfavourable food conditions prevailing at the breeding ground and over autumnal migratory route have been suggested for the above metabolic adaptation. Augmented output of glucagon is supposed to play a major role in mobilization of fat stores. A shift in food habit from carbohydrate to protein and catabolism of muscle protein have been considered for the supply of amino acids for the synthesis of feather protein during postnuptial molting. Complete lack of lipid storage during autumnal migration is a remarkable feature of this species. Nonavailability of carbohydrate rich grains and persistent requirement of energy may suppress lipogenic pathways during this phase. Birds once again change their food liking from insect diet to carbohydrate diet after arrival at the wintering ground (November to July). Greater intake of carbohydrate rich grains probably leads to stimulation of lipogenic activity without any change in the rate of fat mobilization. Thus

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lipogenesis and lipolysis keep pace with each other and birds fail to deposit heavy amount of fat during their stay at the wintering grounds, even though nutritional conditions are quite favourable.

In non-migratory Common myna, inspite of omnivorous food habit and lack of annual cycle in body weight and different body fractions, total lipid content of liver and adipose tissue exhibited a clearcut annual cyclicity. Further, the concentrations of FFA, TG and PL in plasma, liver and adipose tissue; DG in plasma and total cholesterol in liver fluctuated with seasons. However, MG in plasma and liver and DG in liver varied irregularly throughout the year. In addition, levels of glucose in plasma and glycogen in muscle, also exhibited marked seasonal alterations. Seasonal metabolic pattern of Common myna, as indicated by concentrations of different metabolites in different tissues reveal that bird tends to have maximum lipid reserve during the progressive phase (March/April) just prior to reproduction. A sharp decline in TG fractions of lipid in different tissues during reproductive phase (May/June) clearly reflects reproduction to be a major energy consuming event in this species. Onset of monsoon during regressive phase (July to September) of the reproductive cycle when birds are free from parental duties and insects are available in plenty probably help the bird to replenish lipid reserves during this phase. During following preparatory phase (Octobler to February), probably as a consequence of abundant availability of carbohydrate rich grains in nature, anabolic pathways get further activated and lead to deposition of maximum glycogen, PL and cholesterol in liver.

A comparative study of yearly mean values of various metabolites indicate higher values of glucose, FFA, MG, TG, PL and total cholesterol in plasma; FFA, MG, DG, TG, total cholesterol and total lipid in liver and TG, PL and total lipid of adipose tissue in migratory Redheaded bunting than in nonmigratory Common myna. On the other hand, yearly averages of hepatic and muscle glycogen plasma DG, hepatic PL and adipose tissue FFA are slightly higher in nonmigratory Common myna. Although, the two species are differently adapted, yet they exhibit similar circannual variation in the levels of plasma glucose and FFA. This strongly suggests a basic similarity in these two species regarding their need for these important metabolites. Further, FFA cycle in plasma run parallel to the annual gonadal development cycle of both the species. Whether variations in the plasma FFA acts as metabolic indicator for the time of reproduction, is difficult to decide in the present state of our knowledge.

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In both the species, energy is stored largely as lipid particularly TG in adipose tissue. However, the time, rate and magnitude of deposition and utilization vary in the two forms. Difference in pattern of energy storage and utilization appears to be dependent on specific needs of a species.

Migratory Redheaded bunting *Emberiza bruniceps* exhibited distinct seasonal variations in total daily food intake. Birds consumed more food during winter than during spring, summer and autumn months. The total food consumption cycle of Redheaded bunting while showed a close parallelism with body weight cycle from May to February, an inverse relationship was observed from February to May Interestingly, increase in body weight from March to May is not due to overfeeding. In fact, a progressive decline in food consumption occurs during this phase Further, since the rate of whole body oxygen consumption remains significantly unaltered during the time of maximum gain in body weight, it becomes obvious that positive energy balance is not the consequence of either increased caloric intake and/or decrease in metabolic rate. High thyroid activity as indicated by increasing circulating T_4 levels from March to May (Pathak and Chandola, 1982), has been suggested to encourage efficient utilization of food which in turn results in positive energy balance. Thus, the most popular contention that migratory species undergo adaptive hyperphagia prior to spring migration does not hold true in this species.

Experiment was also performed to study the influence of short photoperiod, thyroidectomy and prolactin on body weight and food consumption of migratory Redheaded bunting, *Emberiza bruniceps*. Under constant 9 h daily photoperiod, thyroid extirpation had no influence on body weight and daily food consumption of bird. Injections of prolactin (250 IU/day/bird) for a week was followed by marked increase in body weight of intact birds but not in the weight of thyroidectomized birds. However, daily food consumption of intact, as well as, thyroidectomized birds remained unaffected following prolactin treatment. It is obvious that body weight gain in migratory Redheaded bunting occurs not as a consequence of hyperphagia but only when prolactin and thyroid hormone(s) are available in body fluids of the bird. Profound importance of these hormones has been emphasized during migratory weight gain without hyperphagia in wild population of Redheaded bunting, *Emberiza bruniceps*.

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BIOCHEMICAL BASIS OF PSYCHOSOMATIC CONSTITUTION

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The present thesis has been designed to investigate "Biochemical Basis of Psychosomatic Constitution." The available literature on the subject indicates that scanty work has been done to classify human beings on the basis of morphological, physiological, psychological and behavioural dimensions of human personality simultaneously.

The present study has been undertaken on 150 apparently normal adults of both the sexes. Besides the normal volunteers, 123 cases of various psychosomatic disorders like early thyrotoxicosis, hypertension and bronchial asthma have been also included in order to study the prevalence of the above diseases in relation to different psychosomatic constitutions.

All the normal as well as selected cases of psychosomatic disorders were classified into three morphological groups on the basis of certain anthropometric measurements by calculating the indices of various bony measurements as well as measurement of various soft parts of the body. On the basis of relative predominance of linearity, muscularity and obesity index, we have classified the subjects into three distinct physical groups. Since we have followed the modified Sheldon's technique, we have designated the three morphological types as ectomorph, mesomorph and endomorphs for the sake of our convenience.

Similarly we have also classified human psyche on the basis of certain temperamental traits, like the measurement of neuroticism-index, anciety scale and mental adjustment scale into three psychological groups namely cerebrotonia, somatotonia and viscerotonia.

Neurohumors like acetylcholine, catecholamine and histamine were measured in apparently normal individuals in order to study precise neurohumoral variations in relation to different psychosomatic constitutions. Apart from the above neurohumors various metabolizing enzymes namely cholinesterase, monoamine oxidase (plasma and platelet) and histaminases were also measured in relation to different morphological types. Plasm cortisol was also estimated in normal cases. Total exchangeable potassium and sodium were also considered significant in relation to the regulation of various physiological functionings. Therefore, both have been included in order to study the precise biochemical variations in relation to different morphological constitutions.

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The circadian variation of acetylcholine, catecholamine and plasma cortisol was studied in relation to different morphological types. In certain cases, circadian variation in EEG pattern was also studied in relation to different physical as well as pychological types.

The observed data were statistically analyzed and compared with each other. Correlation coefficient also was calculated with age in order to study changes in above biochemical factors brought about by aging process. Acetylcholine was found maximum in ectomorphs while minimum was observed in endomorphs.

The plasma catecholamine also showed distinct pattern in different body types. Highest values were observed in mesomorph of both the sexes. Similarly males showed higher catecholamine than the females. Catecholamine increases with age in mesomorph but in ectomorph no difference could be seen.

Adrenaline was found more in males than in females in our present series of study. When adrenaline was measured in relation to different body types, maximum level was found in ectomorphs and minimum level was found in endomorphs. Noradrenaline exhibited higher values in mesomorphs and comparatively low values in ectomorphs, of both the sexes.

The psychic type could not show any difference in the level of total plasma catecholamine in male series of cases, while in female series significant difference could be seen when the average plasma catecholamine was compared with cerebro and somatotonia as well as cerebro and viscerotonia.

The adrenaline was found maximum in cerebrotonia both in male as well as in female series of cases. Males have presented higher adrenaline than the females. Noradrenaline was found comparatively more in male somatotonia than other remaining psychic groups.

Histamine level was found maximum in females. When the histamine level was studied in relation to different somatotypes, higher values were obtained in endomorphs of both the sexes. Histamine decreases with aging process,

Histamine, when studied in relation to different psychic types maximum level was found in viscerotonia, both in male as well as in females series of cases.

Cholinesterase was also measured in 83 apparently normal males and 67 females. The higher cholinesterase activity was found more in females than in males. When it was studied in relation to different

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body types, the average value was observed more in ectomorphs and less in endomorphs. Cholinesterase increases with advancing age in both sexes. Plasma monoamine oxidase was found higher in male series than the females. When plotted against age no difference could be noticed in either sex.

Platelet monoamine oxidase, which is fairly a stable enzyme was also measured in 48 males and 30 females. As it is now considered a genetic marker therefore, the estimation of platelet monoamine oxidase has great significance from the point of view of classification of psychosomatic typology. Comparatively higher values were recorded in females than in the males. When it was measured in relation to personality types it was found maximum in mesomorphs while minimum in ectomorphs. On comparison, the differences were found significant in female series of each group while in male series, difference was found significant only between meso and endomorphs.

Histaminase also showed significant difference in two sexes. Higher histaminase activity was noticed in females than in the males.

Age has significant association with histaminase activity. A decreasing trend of histaminase activity was noticed in both the sexes.

Plasma cortisol also showed higher value in apparently normal females than in the males. The average plasma cortisol was found maximum in measomorphs and minimum in ectomorphs in male as well as female series of cases. When it was compared with each other, the differences were found significant in all the three groups.

Higher exchangeable potassium was measured in apparently normal male adults while in female adults it was found comparatively low. When it was measured in relation to different body types, comparatively higher exchangeable potassium was noticed in ectomorphs than the endomorphs.

Exchangeable sodium which is highly dynamic, was found maximum in females. When the sodium level was compared with each other group, the differences were found highly significant in all the three respective body types.

Significant diurnal variation was recorded in the level of acetylcholine when the morning value was compared with evening values in all the three morphological groups. Higher acetylcholine level was noticed in the evening than in the morning. Catecholamine could not show significant difference when the diurnal variation was studied in ecto and endomorphs, but it was found significant in mesomorph when the morning value was compared with evening values.

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Plasma cortisol showed significant variation in ectomorphs when the morning value was compared with the evening value. A similar trend was noticed in mesomorphs also, but in endomorphs a reverse trend was noticed which was statistically found insignificant.

Season has significant influence on acetylcholine, catecholamine and plasma cortisol activity in apparently normal individuals. Acetylcholine, and plasma cortisol were noticed maximum in summer while catecholamine in rainy season. Total exchangeable potassium and sodium were found maximum in winter and minimum in summer. When the average value of sodium and potassium of winter season was compared with summer, the differences were found highly significant.

Electroencephalographic study was also carried out in selected cases of different psychic types. EEG showed specific pattern in alpha activity. In viscerotonia a significant diminition of alpha activity indicates the high anxiety level of viscerotonics, while in remaining other groups, alpha activity is fairly high in comparison to viscerotonia.

Females have shown diminished alpha frequency as compared with males. Similarly there is significant decrease in alpha activity with advancing age.

Acetylcholine was found significantly elevated in all the stress disorders of male series, included in present study.

Total plasma catecholamine showed higher value in all the stress disorders but maximum level was observed in mesomorphs while in endomorphs it was found fairly less than the remaining groups.

Adrenaline was found significantly elevated in thyrotoxicosis and essential hypertension.

Cholinesterase activity was also found elevated in all the stress-disorders but on comparison, the differences were found insignificant in both the sexes.

Platelet monoamine oxidase was found significantly decreased in mesomorph and endomorph groups of thyrotoxicosis and essential hypertension while the difference was found insignificant, when the normal platelet MAO value of ectomorph was compared with all the three stress-disorders in male series of cases.

Histaminase also exhibited higher values in all the psychosomatic disorders but the significant difference could be observed with all the three groups.

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Plasma cortisol also showed elevation in all the three stress-disorders of both the sexes. When it was compared with normal values the comparison was found highly significant in all the three groups of male series, while it was found insignificant in female mesomorph group.

EEG pattern showed diminished alpha activity in all the stress disorders but the diminishing pattern was not identical in all the three groups.

In brief, it can be concluded that neurohumors and their metabolizing enzymes may form a significant basis for the study of psychosomatic basis of human constitution. Till now, no laboratory criterion could be evolved which may not be under influence of age, sex, nutrition, geographical and sociocultural conditions. The role of endocrine factor on human behaviour is well established. There is a need of studying the morphological, physiological, precise biochemical and behavioural dimensions of human psychosomatic constitution simultaneously. Similarly the psychosomatic constitution cannot be studied unless we study mind-body axis. Therefore, the significance of study of adrenal, pituitary hypothalamus cortex inter-relationship has gained maximum importance.

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In stress disorders, there is a marked elevation of various neurohumors and their metabolising enzymes in comparison to normal series. The varying pattern of various humors and enzymes may provide useful basis for the prediction of disease susceptibility in relation to different types.

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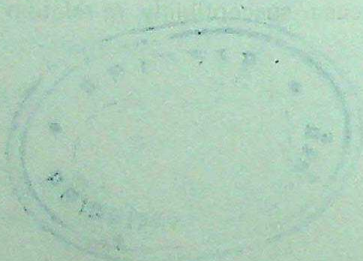

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